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The ADVANCEMENT OF SCIENCE

Vol. X, No. 39

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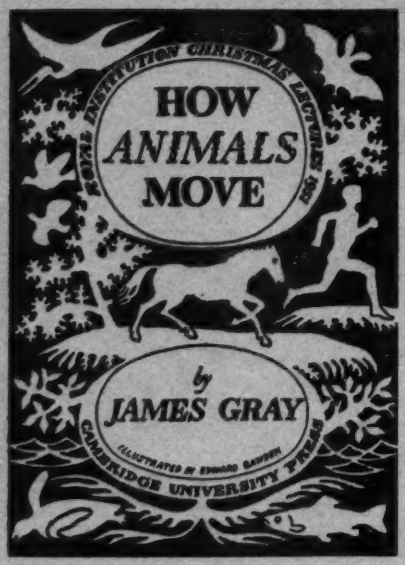

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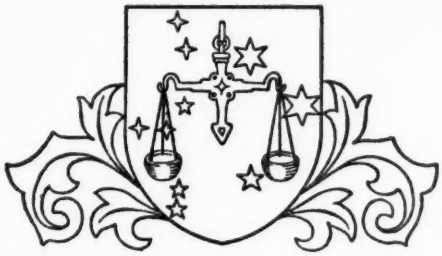
1831  1953

THE ADVANCEMENT OF SCIENCE

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LIVERPOOL MEETING

September 2–9, 1953

THE coming of the British Association to any city, even a great cosmopolitan city like Liverpool, is a notable occasion and the 1953 meeting on Merseyside will be remembered by visitors as one which was marked by gracious and generous hospitality and by the uncommon efficiency of local preparations. The City had already exerted itself over Coronation celebrations and the University had barely recovered from celebrating its Jubilee. Both, in these circumstances, might reasonably have regarded the Association's visit as an undue strain on local resources but, if such thoughts were entertained, it was nowhere obvious that they had been allowed to affect the warmth of the welcome offered to the Association.

Liverpool was no stranger to the Association, having already acted as host at annual meetings in 1837, 1854, 1870, 1896 and 1923. For a convenient, interesting and authoritative review of the high-lights of six meetings (including the one under review) reference may be made to an eight-page supplement published by the *Liverpool Daily Post* on September 2, 1953.

The proceedings of the week in Liverpool were fully reported in local newspapers and in the main national daily newspapers ; an admirable summary, with balanced comment, appeared in *Discovery* (October 1953, pp. 325 and 326) ; *Nature*, *Engineering* and other technical journals have published texts and authoritative articles ; and the *Advancement of Science* will, as usual, contain texts and reports recommended for publication by the Committees of Sections.

On the morning of the opening Wednesday, the President, Sir Edward Appleton, attended a reception in the Tate Hall of the University, where the Vice-Chancellor, Sir James Mountford, received overseas guests. The reception was followed by a civic lunch at the Town Hall where the Lord Mayor, Alderman W. J. Tristram, entertained principal officers and overseas guests. The formal business of the opening day was conducted in the afternoon at meetings of the Council and the General Committee which were held in the Town Hall. At the meeting of the General Committee, Dr. E. D. Adrian, was elected President for 1954 and invitations to hold meetings in the following cities were accepted : Bristol (1955), Sheffield (1956), Dublin (1957). The General Committee received from the Council a report that the custody of the national memorial to Charles Darwin at Down House in Kent, which had been accepted by the Association in 1928, had been transferred to the Royal College of Surgeons of England.

The Inaugural Meeting was held in the evening of September 2 in the magnificent setting of the Philharmonic Hall which is renowned as one of the finest concert halls in Europe. It was preceded by a graduation ceremony at which the Vice-Chancellor of the University conferred the honorary degree of LL.D. on Sir Edward Appleton, Sir Harold Jefferys and Mr. Robert Birley. In presenting the President for the degree, the Dean of the Faculty of Law said that the University was proud to admit into their society one whose indefatigable industry was matched only by his inexhaustible geniality and humanity and that to the untold benefit of mankind. After the conferment of degrees, the President took the Chair and the Inaugural Meeting began with speeches of welcome by the Lord Mayor on behalf of the City and by the Vice-Chancellor on behalf of the University.

The President then delivered his Address on ' Science for Its Own Sake ' (*Advancement of Science*, No. 38, p. 103), which was broadcast direct in the Home Service of the B.B.C. He was thanked by Prof. A. V. Hill, immediate Past President, who said :

' Sir Edward is no stranger to the

British Association ; only two years ago at Edinburgh he had put us all in his debt by the months of hard work he had done in getting ready for our meeting there, and then won all our hearts by the friendliness and gaiety of his cheerful presence at our gatherings. When he told me six months ago of the subject of his address this evening—he called it then " Science for Fun," I shall suggest an even better title later—three thoughts come to me ; one, how well and how charmingly he would do it—in that easy forecast, you will admit, I was right : another, how well worth doing ; and third, how gladly I might have chosen the same subject for myself. For I do agree with his claim—or should it not rather be a confession and apology ?—that the chief and most effective motive of scientific endeavour is curiosity and adventure, and not philanthropy. We deceive ourselves, though perhaps not others, if we pretend it is. The chief reward (I don't say the only reward) is not power or fame for ourselves, or the satisfaction of benefit to others, but the joy of the artist in building a beautiful discovery on skilful and elegant experiment, or the joy of the adventurer and explorer who gets there first. Very rightly he has challenged the notion that romance is driven out by discovery and by understanding of the world around us : to quote Kipling for him against Keats :—

> " By dock and deep and mine and mill
> The Boy-god reckless laboured still."

And when he asked whether some deeper, if more intangible motive and result than material benefit could not be found in the vocation of science, I recalled some words of A. E. Housman, in his inaugural lecture many years ago as professor of Latin at University College.

> " Let us insist that the pursuit of knowledge, like the pursuit of righteousness, is part of man's duty to himself."

'The President has told us a most exciting story about the boisterous worlds which are being revealed to-day by the new methods of radio, at the hands of people, I expect, who are mostly young enough to be our sons : worlds, moreover, which are inconceivably remote from any practical application whether for good or evil, either to warfare or to the welfare state. Many will be grateful to him that, while emphasising how such new knowledge enlarges man's horizon and gives deeper significance to our own world, he has urged the need to recognise still the value of older ideas and ways that cannot be displaced. As he rightly said, there will always be plenty to wonder about ; and wonder is good for the soul.

'In the beautiful work he has described—and I agree with him about the description " beautiful "—Sir Edward Appleton has taken a much larger part than he has allowed himself to say. For many years he was President of that excellent body, the International Union of Radio Science—and he only gave up, I gather, as a precaution when he discovered that all his predecessors had died in office.

'Anyhow it is a very good thing to give up before anyone wants you to. As the Principal of a University he is now, as he says, an amateur scientist—one who does it for the best of all reasons, for love. " *Science for its own Sake*," like marriage for its own sake, suggests too cold a relationship not a bit characteristic of our President. " Science for Love " would have been the perfect title for this admirable Address.'

In the days that followed, the Sections received 295 communications on topics of current interest and importance in 90 sessions of which 8 were joint sessions of two or more Sections. Contributions included many papers on recent advances in research as well as a number of critical reviews in a wide range of subjects. The Sectional transactions are summarised at the end of this volume and the texts of Sectional Presidential Addresses were published in *The Advancement of Science*, No. 38.

The Sections met throughout the University buildings which varied in style from the late nineteenth-century central Victoria building on Brownlow Hill to the Georgian houses in Abercromby Square, and the very recent Department of Civic Design.

There were two evening discourses which were delivered in the Philharmonic Hall. They were given by Sir Ben Lockspeiser on ' Fifty Years of Powered Flight,'

and by Mr. Eric Shipton on 'Everest.' The first marked the jubilee of controlled flight by powered aircraft and the second was a most appropriate subject in a year when Mount Everest was finally conquered. There was also an open session on 'Science and the Unpredictable' arranged by the Division for Social and International Relations of Science. There was an exhibition of calculating machines in the Institute of Mathematics and smaller exhibits were arranged by the British Council and by the Sections of psychology and botany ; the Universities Film Council and the Section of zoology once again arranged sessions of scientific and biological films which drew large audiences.

Encouraged by the success of a programme arranged for senior pupils in secondary schools at the Belfast meeting, the Association arranged a series of non-specialist lectures for young people and adults. The first of these lectures was given by Sir Edward Appleton who delivered a 'Junior Presidential Address,' on 'Finding things out with radio and rockets,' to which only student members were admitted. About forty other non-technical lectures and papers were given during the rest of the week and they included 'Exploding Atoms,' by Sir John Cockcroft, 'Science and the detection of Crime,' by Dr. Keith Simpson, and 'Exploring the Universe,' by Dr. J. G. Porter.

The two main social functions were, as has recently been usual, receptions by the City and by the University. At each of these, provision was made for 2,500 guests. The Civic Reception was held on Thursday, September 3, in St. George's Hall (which has been described as the crowning architectural feature of the City) and in the adjacent Walker Art Gallery where the City's permanent art collection was on view. The University Reception was held on Saturday, September 5, when arrangements for entertainment were supplemented by special demonstrations in many of the scientific and medical laboratories. These demonstrations served to remind visitors of the impressive range of scientific work undertaken by the University and of some of the many famous men associated with that work. Such men included Sir Oliver Lodge (President of the Association in 1913), and Sir Charles Sherrington (President, 1922), both of them investigators and teachers whose greatness had added lustre to the University and the Association alike.

Other social functions included a civic lunch already mentioned, a University lunch at which the wit and grace of toasts and replies was a feature long to be remembered by those who were present : eleven Section dinners and various other informal gatherings. The Engineering Section were entertained at an evening conversazione and, on the Tuesday, 200 members attended a conversazione as guests of local Natural History Societies. On the same evening, the Council entertained principal Local Officers and overseas guests to dinner.

On Sunday, September 6, Officers and members of the Association with representatives of the City and the University, attended a memorable service in Liverpool Cathedral which stands on a high ridge dominating the City. The service was marked by impressive and colourful ceremonial, beautiful choral and instrumental music, and a happy blend of lay and clerical participation in the order of worship. The sermon was preached by the Archbishop of York, Dr. Cyril Garbett, who chose as his subject 'Science and Ethics.' In order that the considered thoughts of one of the most outstanding churchmen of our day on this topic may reach a wider audience, the text of the sermon is published in this volume of *The Advancement of Science*.

Formal sessions were supplemented by a carefully planned programme of about 100 excursions : 25 general and about 75 arranged by Sections. Visits were made to shipyards, local factories and to many places of scientific interest including the Liverpool Observatory and Tidal Institute, the Radio Astronomy Institute at Jodrell Bank, Conway and Bangor Marine Stations, and so on. Members ranged according to their mood and interests from industrial Merseyside to the farming plains of Cheshire and the remote loveliness of such widely separated districts as Snowdonia and the Lake District. As has often happened, the week of the meeting was marked by some glorious days of sunshine : the late bounty of an indifferent summer. The excursions,

tours and visits were not only well planned but also well conducted and the members were able to gather a wealth of information from a civic guide book, an excursions guide book and *The Scientific Survey of Merseyside*, all of which were generously presented free of charge.

The administrative centre and chief rendezvous of the meeting was the Students' Union of the University which was put at the disposal of the Association by the Council of the Guild of Undergraduates who also generously elected all members of the Association to temporary membership of the Union. The Association has rarely had access to a building better suited and equipped to provide for all its needs.

At the first five meetings in Liverpool, attendances were always higher than the average for the decade in which they took place. In 1953, the attendance was 3,506 and although this was substantially less than at Belfast in 1952 (4,600), and at Edinburgh in 1951 (4,012), it was nevertheless more than the average for seven post-war meetings (3,466) : and this in a year when subscription rates for members and associates had been increased by a guinea. More important than the total attendance is the build-up of the aggregate. At Liverpool 53 per cent. of the members were visitors and 47 per cent. were drawn from Merseyside : of the total, 59 per cent. were adults and 41 per cent. were student members ; of the students 67 per cent. were pupils of fifth and sixth forms in local schools and 33 per cent. were students of University standing.

The visitors included many distinguished men and women of science from overseas, among them about 30 invited guests. The Association was honoured by the presence of representatives of Associations for the Advancement of Science in Ceylon, France, India, Pakistan, South Africa and the United States, and of representatives of many of the International Scientific Unions. A congress on ' The deep sea floor and the history of the earth,' arranged by the International Commission on Oceanography brought many of the world's foremost oceanographers to Liverpool and several of them took part in the Association's meeting.

At their final session the General Committee expressed their sincere thanks for, and warm appreciation of, all that had been done in the City and University and the neighbouring districts, to ensure the success of the meeting.

By invitation of the Manx Museum and National Trust, the Liverpool meeting was followed by a visit to the Isle of Man. The President headed a party of about 75 members of the Association who crossed to the island on September 9. Visitors were most hospitably received and were conducted with enthusiasm by their hosts through a programme that began on the day of arrival with a reception by the Lieutenant Governor of the Isle of Man in the Manx Museum at Douglas. In the following two days the programme covered in turn the intensely interesting archaeological, social, geological and zoological history of the island. The President delivered a discourse on ' Science and the Public,' in the Manx Museum on the evening of September 11, before an audience mainly local but including members of the Association and of the T.U.C. who were meeting in Douglas at that time.

Corrigendum : Faraday and the 1837 Meeting in Liverpool.

In his presidential address to Section B at the Liverpool Meeting Professor Clemo wrote 'I looked up the record of the proceedings of the first meeting of the Association in Liverpool in 1837 and was quite taken aback to find that Faraday was its President on that occasion. The Secretary informed me however that, so far as is known, Faraday did not attend that meeting . . .' (*Advancement of Science*, No. 38, p. 120). A correspondent has since drawn attention to a letter from Faraday to his wife which is printed in *Life and Letters of Faraday*, 2nd Ed. 1870, Vol. II, p. 95. The letter is headed ' British Association, Toxeth Park, Sept. 13, 1837 ' and it seems that he was not only present at the meeting but took an active part in it as the newly elected president of the Chemistry Section.

SCIENCE AND ETHICS[1]

by

THE MOST REV. AND RIGHT HON. CYRIL F. GARBETT, D.D.,
ARCHBISHOP OF YORK

And Lamech said I have slain a man for wounding me, and a young man for bruising me : if Cain should be avenged sevenfold, truly Lamech seventy and sevenfold.

Genesis IV. 23, 25.

THIS ancient fragment of poetry follows a brief summary of man's progress from primitive savagery into the first stage of civilisation. Lamech's three sons represent the advance man has made : Jabal has left the cave dwellings for tents, and from a hunter dependent for his food on bow and arrow has become a herdsman owning cattle ; Jubal is the father of music handling harp and pipe ; Tubal-Cain has emerged from the stone to the iron age, and is the forger of cutting instruments of brass and iron. Lamech has good reason to welcome this threefold advance in pastoral life, in culture and in technics. But his rejoicing is confined to one aspect of this advance. In the forging of brass and iron he sees the possibility not of tools which will enable him to reap more fully and easily the fruits of the earth, but of lethal weapons with which he can destroy his enemies. Now with iron he can kill more effectively than with the stone weapons of the past. With boastful arrogance he declares he has slain a man who has wounded him and a young man who has bruised him, and exultantly he sings. ' If Cain shall be avenged sevenfold, truly Lamech seventy and sevenfold.' An invention which should have brought to man greater prosperity and happiness is to be used for death and destruction.

THE USE AND MISUSE OF SCIENCE

The history of civilisation shows how man always has to choose between making the right and wrong use of the discoveries of science. This has never been more true than in our own age. In a brief period amazing discoveries have been made and applied to practical purposes. It has become a platitude to say we are living in an age of revolution. Within the lifetime of many of us the social and economic life of a great part of the world has been transformed by science.

It would be ungrateful not to recognise how immense are the boons which science has given to mankind. It has brought within the reach of multitudes benefits and advantages which only a short time ago were the privilege of the few. It has shown how malnutrition, hunger, and disease can be overcome. It has not only lengthened life, but it has deepened its quality. Fields of knowledge, experience and recreation open in the past only to a few have been thrown open to millions. Through the work of science the ordinary man to-day has been given the opportunity of a longer and fuller life than was ever possible to his grandparents. Most thankfully we must acknowledge all that science both has done and is doing for the welfare of our race.

But the gifts of modern science can be misused as greatly as those of primitive science in the days of Lamech, and as the gifts are greater, so their misuse can be the more catastrophic. The motor driven vehicle facilitates business and gives harmless enjoyment to many ; but it can strew the roads with dead and dying—250,000 casualties in one year in this country alone. The cinema is a means of instruction and recreation opening ' magic casements ' but it is often a channel of vulgarity and false values. The wireless can link the world together in a moment of time, but it can also be the instrument of lying propaganda. The aeroplane

[1] The sermon preached in Liverpool Cathedral on Sunday, September 6, 1953, on the occasion of the meeting of the British Association.

makes travel rapid and easy, but it can also become a weapon of destruction.

The Dilemma of Science

It is this twofold aspect of the use to which science can be put which has raised in an acute form the question as to how far it is morally justifiable to make and perfect discoveries and inventions which can be used for purposes of destruction or result in the ultimate impoverishment of man. This, if I understood it rightly, was the dilemma posed by Prof. Hill in the remarkable address he gave from the Chair at last year's meeting of the British Association. He summed it up in the question: 'If ethical principles deny our right to do evil that good may come, are we justified in doing good when the foreseeable consequence is evil?' He drove home this question by two problems. The first was taken from the development of nuclear physics. This, rightly used, should be of the greatest value to mankind, especially if existing sources of power come to an end. But at present the development of this science is largely with the object of producing weapons, like the atomic and hydrogen bomb, of unprecedented destructive power. Is it right therefore to continue research on lines which may lead to fearful destruction, and is it right to keep secret the result of these researches? The other problem arises from the success of science in overcoming disease and lengthening life. Both the birth rate and the expectation of life have been increased by the removal of the older checks of hunger and disease on the growth of population. But the supplies of world food are not increasing at the same rate. Before long population will have outstripped the food available to feed it. When this happens the scramble for it will be intensified as the world becomes divided more than ever into 'Haves' and 'Have nots.' War for the means of existence will be inevitable, and in the fight against starvation the land will be exhausted and soil erosion will change fertile plains into dust bowls. Is it right to continue improving world health and reducing mortality if by doing so future famine and disorder become certain? These and other questions are a challenge to thoughtful men. *The Times*, in commenting on this address the next day, said it was a call for a statement of moral principles, and continued, 'Theology was once known as the Queen of the Sciences. If science as the servant of humanity is to be sure of its direction, the queen needs to be either re-instated or replaced. . . . The throne is at present vacant.'

Integrity and Secrecy

To the questions thus asked Christian theology must attempt some answer, though often it cannot be clear cut and decisive. The Christian theologian is in complete agreement with the man of science when he asserts that the fundamental principle of all research work is unbending integrity, and that evidence must be followed to its logical conclusions however disagreeable they may be. The Christian must welcome truth from whatever quarter it comes, for his Lord is the Truth as well as the Way and the Life. A sound Christian theology insists that the love of truth is as important as the practice of truthfulness. It is deeply to be regretted that sometimes Christians have forgotten this and denounced new discoveries, not because they were untrue, but because they feared they would be dangerous and unsettling to faith. The Christian has the right to criticise the validity of any theories. It may be necessary for him to suspend for a time final judgment on them, but he has no right to reject them solely because their consequences may be disconcerting. Neither Church nor State must attempt to destroy the results of scientific enquiry. The Church must not repeat the condemnation of Galileo nor the State the folly of Stalin on the Lysenko controversy on heredity.

The unrelenting search for truth does not however carry with it the conclusion that when discovered it must at once be proclaimed to all and sundry. Men of science have always taken pride in the universal nature of their work; in the past they recognised no national or geographical boundaries, and they were able freely to exchange information with fellow workers in different lands. It is therefore repugnant to them when secrecy is imposed upon them. With this position Christianity fully agrees, for as it teaches

the Fatherhood of God and the brotherhood of man, we should share unselfishly with others our knowledge and advantages. But Christian theologians have also recognised that there must sometimes be reserve in imparting truth, for there are many who are still incapable of receiving it, and to some it would be like the casting of pearls before swine. Truth must be imparted according to the measure in which men are capable of receiving it and using it rightly. The Christian moralist therefore holds that discoveries and inventions can be justifiably kept secret from those who might use them for evil purposes. A state is within its rights in demanding that secrecy should be observed about inventions made by those whom it has employed when they are intended for its security but might be used by an enemy for its destruction. This secrecy is a temporary expedient due to the evil times in which we live.

The Christian Answer

It is over the application of science to human life that moral problems arise most sharply. The Christian approaches them with the conviction that every individual is of value. He is not alone in this conviction. Many who are not Christians hold it equally strongly, but the Christian conviction is founded on the belief that God Who is Love has made man in His image, so that He can love man and man can love God. Man is of value, for he is of divine origin and destined for eternity. It was natural therefore that Christ should have branded contempt as one of the gravest of sins, for who are we to treat as fools or worthless, those whom God loves? If once the value of the individual is discarded, the way is thrown open to the theories of race superiority which divide mankind into master and slave races. These were carried to their logical extremity by the Nazis in their hideous massacre of all who had Semitic blood, by their enslaving of non-Aryans, and by their liquidation of those who through feebleness of mind or weakness of body were likely to be a burden to the State.

All who believe in the value of the individual are therefore bound to ask of any discovery or invention whether it will heighten life or destroy it. But life to the Christian means far more than physical life, for man has a soul as well as a body, and the physical side of his personality may be developed at the cost of the spiritual. The Christian must go on to ask whether a new discovery can be so applied as to enrich the whole of man.

Nuclear Warfare

Tested by this standard, all methods of mass destruction whether by bomb, by nuclear weapons, by gas, or by bacteriological warfare, are condemned, for they destroy as worthless flies those whom God loves and has made in His own image. Their special wrongfulness lies in the contemptuous and indiscriminate destruction they bring upon masses of men, regardless of whether they are combatants or non-combatants, or of sex or age. The total abolition of war and its causes must be the ultimate goal. To reach it will be a long and difficult journey. But as in the past certain methods of warfare were successfully banned as contrary both to natural and divine law, so in our century it should be possible for the world of nations to discover means by which indiscriminate destruction could be outlawed. No one nation can do this in isolation, for if it threw down its most effective weapons of defence it would only incite attack from its rivals who had remained fully armed. Unilateral action of this nature on the part of a nation might secure for it some physical safety, but at the risk of losing its soul, for if it should come under the totalitarian yoke, its citizens would soon lose all that makes a full life possible, for man has a soul as well as a body, and 'what shall it profit a man if he loses his soul?'

The terrible dilemma between refusing to make these weapons and thus endangering the freedom of a people, or making them and then employing them for appalling destruction, can only be solved by international agreement with effective inspection and drastic sanctions for any breach. All men of good will should urge that at the earliest practical moment renewed attempts should be made to forbid the making or the use of these weapons of mass destruction. Until such an effective agreement is reached the world is threatened with destruction.

Population and Hunger

The same principle of the value of the individual demands that everything possible should be done to preserve life. Once a human being has been born he has the right to live, however lowly or even degrading may be the circumstances of his birth or his social environment. The Indian, the Chinese and the African have the same right to food and health as their more fortunate white brethren. Science has shown how crops can be greatly increased by new methods of agriculture, and how disease can be reduced or banished. But it can do comparatively little unless the more prosperous communities are prepared to make sacrifices for the sake of saving the backward peoples from destitution and starvation. Such sacrifices may mean that the more prosperous nations will have to accept for a time a lower standard of living for themselves.

It is only when food is no longer the chief preoccupation in life and the struggle for bare survival is relaxed that man has leisure to concern himself with the quality of life. Only then will it be possible to educate him into a sense of parental responsibility which will prevent him from bringing into the world more children than he can reasonably hope to support. For however great may be the increase in the food supplies of a country, the growth of population will soon again outpace them if parentage is without foresight, and the birth rate of backward countries continues to multiply. Side by side with the aid that science can give in the production of food and against disease there must be moral and religious education in both the responsibilities and restraint of parenthood. The quality of life is more important than numbers.

The Responsibility of Men of Science

The right use of the discoveries of science depend therefore not so much on those who made them as on the moral judgments of the community. Man's inventive genius has grown out of all relation to his sense of moral responsibility. He has advanced in technology, but there has been no corresponding advance in his mastery of himself. He has learnt to work in harmony with the laws of nature more quickly than he has learnt to live in harmony with his fellow men. He has acquired inventions and tools long before he has learnt to use them rightly and wisely. So, like Lamech, he has frequently turned to destructive purposes what should have been used for the common welfare. The use or misuse of science depends on the moral judgments of society, and the Christian believes that right moral judgment depends ultimately upon religious faith in the Sovereignty and Righteousness of God.

Men of science have sometimes claimed that when they have made a discovery they have no more responsibility for the use made of it than any other citizen; but in actual fact this is not the case. For they have an influence over contemporary thought and action which is possessed by no other class of men. They are listened to attentively by those who pay little heed to the ecclesiastic, the philosopher or the poet. Often their casual opinions, even on subjects outside their special field, are given reverent attention. They cannot therefore say of any of their discoveries: 'Take them, and use them as you think fit; this is not our responsibility.' They must take an active part in educating their fellow countrymen to use rightly the inventions they have given them. They must make plain the terrifying results which may follow the wrong use of some of them.

We thank God to-day for the love of truth and the unremitting search for it by so many who have given their lives to science. We thank Him for the rich benefits their discoveries so often have brought to mankind, but we must also pray that their inventions may be used for life and not for death, for the development of personality and not for its destruction, for the benefit of all and not in the service of greed or the lust for power, and that the ideal which scientists may have ever before them is the discovery of truth for the glory of God and for the good of their fellow men.

THE MUSEUM PRESENTATION OF SCIENCE[1]

by

DR. DOUGLAS A. ALLAN

MUSEUMS fall into two major groups—art museums, in which any object has a more or less profound and largely emotional appeal on its individual merits, and science museums, in which the appeal is to reason and the individual specimens build up into some comprehensive generalisation or theory. Science museums are thus storehouses, sheltering examples of the material of the earth, its dwellers, vegetable or animal, and the products of man's hands and brain in so far as they fall short of the category of works of art. Historical museums may be classed with the science ones, although individual items, away from their context, may be of high artistic merit. As science has marched, and marched notably with the passage of time, so our science museums reflect clearly the period of their foundation, the function for which they were designed, and the financial resources which have encouraged or prevented their development. Many of our greatest museums, both national and municipal, originated in the middle of the last century as repositories for systematic collections, geological, botanical, zoological and archaeological, together with the instruments employed in their determination or treatment. Such collections were regarded as essentially reference material to be appreciated and used by the studiously minded, who had already invoked the aid of textbooks or expert lectures. To the general public of the day they were, on the whole, places of occasional resort wherein extremes met—and on both sides of the glass—the very old and the extremely recent, the choice and the commonplace, the almost invaluable and the nearly worthless, as far as market values go. Other museums were begun in association with local learned societies, housing the study series of enthusiastic amateurs, the findings of Saturday field excursions, and the treasures of foreign travel. Yet a third group developed as part of the teaching equipment of colleges and universities—departmental museums in which the casualties due to class handling tended to be made up by the influx of research material or the contributions of grateful alumni. These museums enjoyed a clientele which had already an interest in or had accepted an obligation to interest themselves in the subjects dealt with ; they were preaching largely to the converted.

Later on, the appeal of science began to reach out to a much wider public, whose appetites for knowledge had been stimulated by popular press articles on exploration or investigation of one kind or another, by the rising tide of attractively written books on every aspect of science, and by the often notably individual personalities, who constituted the *corps d'élite* of university, laboratory and expedition. In the days of H. G. Wells' earlier novels, science was something one had to ' go in for ' and it called for material and apparatus such as the man-in-the-street could only find within the walls of a science museum. To meet his demands, museums had to advance, and advance rapidly, from collecting, labelling and presenting scientific material to elucidating it and to explaining scientific ideas. Each specimen had to be set in a special association with others, their relationships had to be demonstrated, and the generally accepted deductions drawn. To responsibility for reliability in identification was added that for disseminating scientific thought—for sponsoring, to a certain extent, scientific theories. In this, however, the science museums merely stepped alongside the art museums, which had always accepted as their lot the setting of standards in taste and execution. Moreover, henceforth the science museums

[1] Text of a paper read to the Assembly of Corresponding Societies at the Liverpool Meeting of the British Association, September 7, 1953.

had to reach beyond their own cases and galleries and encourage the beginner in any field to look with his own eyes for appropriate material in the world out-of-doors and to add to his knowledge by means of library books and lecture courses. Museums had become the After-Working-Hours University.

The museums presentation of science began, as one would expect, with those sciences which were already widely represented in their collections, those which were most commonly dealt with in press and magazine, and those which lent themselves particularly well to contemporary techniques of museum display. In nearly every case these were the natural sciences, with the emphasis on geology, in which the material could readily be presented in its normal condition, and zoology, in which mounting methods had reached a high level of realism, in response to the demands of sportsmen and collectors. In botany it was difficult to employ actual plants except as living examples—growing or on the plant table—or as dried herbarium specimens. So, to this day and the world over, science museums devote themselves very largely to geology and zoology, in which a wide range of interesting specimens is available, can be preserved for a long time by relatively easy methods, and can illustrate an almost endless variety of scientific themes and ideas with a minimum amount of background knowledge. In the case of botany, the evanescent raw material has had to be replaced by models in sheet metal, in porcelain, in wax, in glass and in plastics, or by specimens preserved in a range of solutions, the search for the most successful and lasting results being still under way, for it is the fundamental conception of museum work that it is based on three-dimensional objects—original if possible, with here and there a copy if necessary, and a reduced one where space is restricted.

Serious study rapidly increased the demands from single specimens to groups illustrating comparisons, functions, development and associations. Labels expanded from austere identifications and brief descriptions to simple expositions of interpretations and ideas, to aid which were enlisted diagrams, photographs and models. This progress in presentation met the needs of the student or the interested visitor who was in search of information. For the many who merely drifted through museum halls and galleries devoid of any particular aim, so-called arrest features were introduced—attractive arrangement, the use of colour and special lighting, large and impressive specimens at intervals, working models, talking labels and a host of other devices involving what our American colleagues call ' audience-participation.' This has naturally reduced the amount of real specimens in museum presentation, for the mounted birds on stands swelled to a section of hedgerow or hillside with plants, nest and young, and thence to whole ecological groups of animals at a waterhole or the denizens of the foundations of a coral reef. Like certain prehistoric monsters, these seem to have come to a natural end, for their size and cost appear likely to preclude the construction of further examples even in the wealthy U.S.A. Nevertheless the essence of the problem remains the same—to get hitherto uninterested people to stop and inspect the exhibit so closely that questions arise in their minds, questions to which the adjacent labels may be expected to provide the answers.

The main drawback to the museum presentation of the natural sciences was that the exhibits were static, although the imagination of the onlooker could supply the missing movement. To their aid came the moving picture showing flight, food gathering, nesting habits and so forth, with the gramophone bringing bird song into museum galleries. Processes normally too slow or too fast to be observed in the time available could be geared to suit public needs, while the combination of cine-camera and microscope could probe more deeply into nature's wonders than ever before, providing further material to support museum specimens and labels. The sound film in natural colours would seem to be the goal, already most successfully achieved in this field, whether one seeks the greatest realism in ' widies ' or ' deepies,' but, just as some museums have eliminated reflections so completely from their glazed cases that a white cross has to be painted on the glass to prevent damage to plate or public, so discretion must be used in projecting unwarned and

unarmed visitors into some deep sea drama or jungle tragedy, no matter how authentic.

So much for the natural sciences. How far have our museums gone in presenting the chemistry-physics-astronomy group? In most institutions these found a place at a later period than the others, and a variety of reasons may be advanced for this. On the whole they demand a greater background knowledge, such as, in the nineteenth century at least, was not to be found in one's day-to-day travels. Raw materials and apparatus cost money, experiments in the home required space, and were often regarded as obnoxious if not really dangerous. Here was no pleasant outdoor hobby. There was thus no generally interested public demanding museum exhibits, while the actively interested students found their needs better met in classrooms and laboratories. For a considerable time these sciences were relegated to somewhat gloomy rooms, housing rows of bottled samples, an array of antique apparatus, sometimes associated with distinguished pioneers, and often rather faded photographs of these gentlemen and their discoveries. Later the coal, oil and chemical industries came into their own and provided fascinating introductions to applied science by exhibits of raw materials leading through processed samples to the end products, set against scale models of factories with detailed equipment. Such displays were often the first steps in chemical knowledge for the general public.

Again the science museums marched with progress, invention and practice in these fields. The First World War gave an immense fillip to general interest in chemistry and chemical industry—high explosives and poison gas led to vitamins and drugs. The years between saw air transport become a commonplace and the radio invade the home. The Second World War provided wizardry ranging from radar to atom bombs. The finest and most expensive habitat group became neglected in favour of the latest man-made mechanical marvels, and museums with adequate space, funds and staff had to instal vast new exhibits tracing from first principles the development of modern inventions up to the day before yesterday, forecasting, if at all possible, what was likely to be the shape of things to come in several years time . . . Zoology, geology, botany—then chemistry—and now physics, magnetism and electricity. . . . But the principles of museum presentation remain very much the same. There must be utter reliability, lucidity and artistry. More than ever is the problem one of demonstrating processes but more than ever are mechanical aids available, working models, power-driven components and cinematograph films. In addition, at no time in the history of our museums has there been so large a proportion of our visitor population equipped with so great an amount of scientific and mechanical knowledge, thanks to the recent war of machines and the mechanisation of daily life in home and factory. Wonderful new fields are available for science museum displays, and a vast amount of public appreciation is there to support our efforts. In exhibits dealing with physics and chemistry, again the main difficulty in attracting public interest has been the static character of apparatus, which was made to be used, and of the rows of reagents, raw materials and end products meant to interact upon each other; in trying to understand them, the uninformed visitor, unlike his neighbour in the bird gallery, has no experience to stimulate his imagination. Small, onlooker-operated films can be employed to show processes actually going on, but better still are such experiments as can be demonstrated by staff in attendance, as at the Palais de la Découverte, Paris, or, where some kind of endless chain apparatus can be devised, conducted by the visitors themselves, as is done at the Museum of Science and Industry, Chicago. When we come to applied science—technology and engineering—we are faced with very serious problems of expense; as in erecting an imitation coal-mine as a background for lamps and tools, in constructing accurate scale models which must, in many cases, be power operated by some simple controls at the disposal of the onlookers, and in maintaining them in working order despite an almost punishing use by the general public. One Sunday afternoon, a Royal Scottish Museum model was set in motion 1,000 times in three hours, averaging once every ten seconds. To keep a hall of working

models for public interest and education is like running a fleet of motor cycles if not motor cars.

As the floor space and the staff of even our largest and wealthiest museums are limited, and only at lengthy intervals does each enjoy an increase, it is clear that selectivity must be exercised in determining the offerings to be made to the public. Here it is necessary to emphasise that museums must serve in one way or another the whole public, and from fairly wide experience one can divide them into those who come with a general background of knowledge and those who come with specialist training. For the first, all the lures of spacious lay-out, artistic display, lucid exposition and arrest features are necessary ; for the second, an adequate range of exhibits, simply arranged but technically described, is what is wanted. The first must have the ground floor and the front section for they have to be attracted off the street ; the second will gladly find their way to more distant parts—and will in time be joined by the more valiant searchers after truth from the first. For the general public there should be specimens and apparatus to illustrate the fundamentals of the science in question —the typical rocks, fossils, minerals, birds and mammals, elements and compounds, acids and bases, prime movers and so on. Then come principles of classification, function and operation, leading to generalisations with outstanding examples. In the smaller museums, emphasis may be laid with advantage on local examples as an encouragement to 'go and seek for yourselves.' In the same way, chemistry and applied chemistry can be linked with any appropriate local industry. An additional series of exhibits can be devoted to the development of the apparatus of the science or industry, showing how, as with artillery, advances extend the range, increase the power, and enhance the precision achieved. Again there is often a direct appeal in economic aspects of science, such as the relation between crops and pests or insects and disease.

Museums are public repositories and public resorts. They have to save scientific material—type specimens, original apparatus, the research material of yesterday that may well be required in the investigations of to-morrow, the local collections of a rural area now engulfed by the bricks and concrete of urban advances, and the historic machines that would otherwise end in rust or scrap ; they have to make that and other material available for the recreation and education of the public resorting to them. While museum displays for the general public must contain adequate linkage between object and object, they must not be gigantic textbooks with a few specimens as illustrations to a mass of labels. In a museum the first consideration must be to provide an ample range of specimens for the edification of the visitor, who uses the text to tie them together into a coherent story, who employs his eyes and his brains to test the truth of this story as far as he can, and who carries away new ideas to be tried out elsewhere. That is the function of museum education. Despite the marvellous inventions of modern science—movies and talkies, invisible ray controls, guiding lights and glittering gadgets, the best link between the museum display and the public—the best method of presentation—is *homo sapiens*. The skilled and understanding guide lecturer and demonstrator, who knows both his subject and his public, can without doubt achieve very much with comparatively little. He can hold his audience, he can carry his theme forward, emphasise a point and answer a question. If he cannot be available to guide parties, he should at appropriate times give talks and demonstrations in a convenient lecture room. Failing a human mentor, reliance must be placed upon brief, simply phrased and interesting labels, composed with the aim of drawing attention to salient points, fitting the specimen into the story, and anticipating, as far as possible, questions and criticisms. Nor is that the end, for the good work done by tour and talk should be driven home by well written and adequately illustrated handbooks which can be taken away by the visitors, consulted at leisure, and employed as a lead-in to utilisation of the nearest library, enrolment in appropriate classes, and membership of some suitable society.

So far, little has been said about astronomy. It is a difficult subject for museum treatment. There are telescopes, but,

save in a very few instances, one cannot look through them ; models of the sun, earth, moon and stars, but generally on distorted scales ; orreries, usually regarded as mechanical oddities ; and a series of photographs. Yet the public interest in astronomy is undoubtedly great, and a natural science museum which attempts to depict our world and its setting can hardly afford to neglect the subject. One or two large centres have catered for this interest by installing immense and expensive planetaria, and now a much cheaper model is available for small museums. Yet it is doubtful if they are more than wonderful toys playing with entrancing patterns of imitation stars, planets and moons to most people, who pass their turnstiles, for they do not see anything long enough, or hear anything emphatically enough to remember. Reading no labels they indulge in no audience participation and there is not even a Hollywood plot to fix the theme in their memories. It would seem that in the case of astronomy, more than any of the other sciences, the amount of background knowledge necessary for the appreciation of the models, diagrams, instruments and photographs demands the careful reading of a textbook or attendance at a course of lectures preferably beforehand or at any rate *pari passu* with the study of the exhibits—and these, after all, are but makeshifts for the actual bodies to be seen in the heavens themselves, to which it is the major aim of author and teacher to direct attention.

Wherever it is possible, it is always advisable to leave some part of the hall or halls clear of any permanent displays, so that accommodation can be provided, without undue disturbance, for temporary exhibitions. These can be of very great advantage in providing variety of fare and encouraging successive visits, in giving opportunities to stage displays on subjects of interest but not important enough to demand a permanent site, and in attracting public attention to new discoveries, inventions of topical appeal, or to the treasure-trove of expeditions from far afield, the material for which may be borrowed only for short periods. Such a policy undoubtedly contributes greatly to make a science museum a live institution, but takes trouble, time, staff and funds to carry out successfully. It necessitates contacts with universities, research institutes, industry, societies promoting exploration projects and, above all, the press, both specialist and popular. It calls for courage and persistence as research experts are often uninterested in public reactions, industries may not desire publicity, and exploration committees may have sold their wares elsewhere. On the other hand, some of these bodies, like I.C.I., the petroleum companies, or the nationalised industries, are financially able to stage first-class exhibitions ; they should be encouraged to join with museums in the scientific education of the public.

In yet another way have these temporary exhibitions a very important role to play. Museum architects and administrators, like universities and textbooks, tend as a matter of convenience to divide science into watertight compartments. This is a profound mistake for science is indivisible. The demonstration of the contents of the borderland and of the nature and importance of the fusion points of neighbouring studies can provide entrancing museum displays and awaken new interests. Among them may be mentioned the association between rocks and vegetation, between palaeontology and palaeobotany and their modern equivalents, between physical chemistry and petrology, and between microbotany and stratigraphy in geological and archaeological investigations.

Our museums, ever since their inception, have been engaged in the task of presenting science to the public, employing their unique combination of collections of real objects and staff of proven ability for the purpose. As the sciences evolved, the staffs have extended their own knowledge of the subjects concerned, of improvements in the technique of museum presentation, and of the calibre of their clientele. Museum education, perhaps even more than any other kind, is perpetually experimenting, evolving and advancing. What was done last week can be modified this week and improved upon the next. It takes toll from all the arts, all the sciences, and industry in all its aspects—and, even so, we know it could be better than it is, wherein, in all probability, lies

our salvation. Many museums, for lack of funds or staff may be struggling along with unimpressive results, but there are numerous examples, particularly in the British Commonwealth, in Western Europe and in North America, which are outstanding for their up-to-the-minute educational work in scientific fields. To mention but four, in Europe, outside the British Isles, there are, in order of foundation, the Deutsches Museum in Munich, the Tekniska Museet in Stockholm, the Palais de la Découverte in Paris, and the Museum of Science and Technology in Milan, all dealing with the physical sciences. In North America, most impressive work in the natural sciences is performed by the American Museum of Natural History in New York, by the Chicago Natural History Museum in Chicago, and by the National Museum of Canada in Ottawa, to quote but three. To whom do they offer scientific ideas, old and new? To everyone from the research expert, the family on tour and the adult education group to the hobbies club and the school class, and in this work they employ the exhibits and their labels, the guided tour, the demonstrator in the galleries or at his laboratory bench in the lecture theatre, the handbook and the film show, and, beyond their own doors, loan material and touring exhibitions.

In presenting science to the public, museums are in line with libraries on the one hand and educational institutions, like colleges and societies, on the other—with recorded knowledge and its systematic exposition. Utilisation of these two services demands a certain amount of effort, of concentration and of comprehension. So also must the museum, and we have to beware in our planning and progress lest we oversimplify and overstreamline our displays, making either untenable generalisations or but limited calls on effort or imagination. Museum exhibits are unique in that the evidence for any statement or any generalisation is laid before the observer, and our function is not to project him unerringly and unresisting to a conclusion, but to encourage him to note the evidence —both for and against where possible—to weigh it, and to be satisfied that the conclusion offered best fits the case. When we achieve that, we graduate from producing scientific sideshows to promoting the scientific outlook.

THE PLACE OF FORESTRY IN BRITAIN'S ECONOMY[1]

Address by

A. P. LONG, C.B.E.

ALTHOUGH for many generations woodland has formed a characteristic feature of rural Britain forestry has never assumed the role of a major industry in these islands. Most of the timber felled during the second World War was planted over a range of 120 years between the years 1800 and 1920. The older trees were mostly hardwoods overlapping younger but mature pine and larch. In early days the woodlands were severely depleted by the removal of large, heavily branched oak for shipbuilding purposes and future supplies became a matter of national concern which led to considerable planting of oak, largely in the Crown forests. This continued until iron ships began to replace wooden ones from which time onwards there was no apparent policy and no guidance from the State until the beginning of the twentieth century. Private woodlands, which formed some 97 per cent. of the whole, were managed to suit individual owners, who in many cases took pride in their timber and showed much enterprise.

Throughout the nineteenth century the demands for timber changed from hardwoods to softwoods and as the home woods could not supply the ever increasing demands for cheap softwood timber a great import trade was built up. Woodland management responded slowly to the changing demands and the hardwood and coppice areas mainly persisted until the small material and bark became unsaleable, but these woods had a high sporting value and their replanting with softwoods was made less pressing. In Scotland sylvicultural conditions were more favourable for the growth of the indigenous Scots Pine and the Larch which was introduced in the early part of the eighteenth century and these were mostly cultivated, sometimes on a relatively large scale. During the nineteenth century Douglas Fir, Sitka Spruce and Japanese Larch were introduced and these species proved to be particularly suitable for our conditions. Thus, coupled with the continued use of native and European species, the stage was set for an attempt to build up coniferous forests capable of producing good quality timber relatively quickly.

This coincided with a quickening interest by the State in the future of the country's timber supply and a number of official inquiries produced several reports which all advocated alternative schemes for State Afforestation. Nevertheless public opinion was not aroused until the lessons of the first World War had been learned and it was not until 1919 that the first State Forest Authority was formed in Britain.

This authority, the Forestry Commission, embarked upon a considerable programme of afforestation but economies imposed during the inter-war period prevented its fulfilment and it was not until after the further experience of the second World War that the need for energetic action in restoring, even increasing, the home timber resources became really apparent.

The primary object of afforestation in this country is the production of timber, so let us examine the facts briefly.

For long most of our timber needs have been imported. In the five years immediately preceding the second World War our consumption was over 1,000 million cubic feet, consisting of 93·8 per cent. softwoods and 6·2 per cent. hardwoods of which only 4·2 per cent. was home produced. Since the war the position has

[1] Chairman's Address to Forestry Sub-Section, delivered in Liverpool, September 4, 1953.

been vitiated by many considerations and the fluctuations have been considerable but the general pattern is similar in that the United Kingdom is still far and away Europe's largest importer of both softwood and hardwood timber. In 1950 we imported 93 per cent. of the total softwood consumed and, in spite of large fellings at home, we imported nearly two-thirds of the total hardwood consumed.

Taking the European position as a whole, the recent report of F.A.O. (1) states there is a gap of 85 million cubic metres, being 24 per cent., between requirements and supply, whereas the estimated requirements of all industrial forms of wood will be between 9 per cent. and 19 per cent. higher in 1960 than was consumed in 1950 ' there is the danger of a trough in European timber production lasting for the next 20 or 30 years,' and in the immediate future the maximum exports from non-European countries will be 14 per cent. of estimated consumption. Side by side with this reduced production it is estimated that (provided the 1950 prices remain constant) the requirements of all classes of timber in the United Kingdom in 1960 will be 40 per cent. higher than the consumption in 1950 which however will still be 15 per cent. lower than in 1935–38 and in future years the consumption per head of population will continue to rise. It is concluded that the United Kingdom's hopes of getting full supplies during the next 20 or 30 years are slender.

From the economic point of view the position is even more serious. The average total value of timber imported each year during 1934–38 was £62,800,000. Last year we spent £90 millions in importing little more than half the quantity. It is estimated that prices will rise but even if they remain constant we shall be spending more than £100,000,000 in 1960 if the estimates of consumption prove to be correct.

Such facts indicate that both from the supply and economic aspects it is not only expedient but essential that the United Kingdom should produce more timber at home.

As the conditions at home are very favourable to the growth of trees at a more rapid rate than in most countries and since there is a considerable area of land of a low order of production in the country the desirability of doing so is greatly emphasised.

The rate of felling and therefore the reduction of timber resources in these islands is greater than was anticipated in 1943 when the Commissioners' Post-War Policy was first announced. As the F.A.O. report shows the European position to be no better than it was at that time, it follows that the programme which was accepted then has more reason than ever for support to-day. In the words of the Chairman, Federated Home Timber Associations, ' The country cannot afford to spend any foreign currency on the importing of wood of any sort that can be equally well provided from home sources. Just as we as a nation must grow more food—so we must produce more wood at home. The forester and the home timber merchant are as important to the nation as the farmer, and in exactly the same way. . . . But the Government have realised that we cannot spend foreign currency unnecessarily. They have suspended the issue of all licences to import hardwoods from all non-sterling countries except a privileged three with whom we have special trade agreements. The N.C.B. have declared publicly their policy to absorb all suitably prepared homegrown pitprops within their specification first, and then to adjust their purchases from abroad accordingly.'

Let us consider the various aspects of that programme, namely the achievement of 5,000,000 acres of well-managed forest within 50 years, made up of the rehabilitation of 2,000,000 acres of existing woodlands and the afforestation of 3,000,000 acres of new forest upon land which is not now carrying trees.

It is estimated that such a programme will only produce 30 per cent. of our normal requirements or alternatively provide enough timber at home to carry us over an emergency lasting for five years. In these days of uncertainty the latter is a very material consideration for the development of submarines and other armaments will undoubtedly make the passage of ships on the high seas in war time more and more hazardous. How great an asset the home supply of timber can be during

a war will be appreciated from the fact that during the first World War the shipping space saved by the restrictions of timber imports, which were made good from home supplies, equalled the total tonnage of shipping lost by submarine sinkings. So the urge for home production, especially of such bulky material as timber, is all the greater.

For normal purposes the import of timber is a very considerable drain upon our financial resources, especially as much of it comes from hard currency areas. So important is this feature that imports are rigidly controlled; we now import only about half the volume imported in 1934–38 and the demand greatly exceeds imports. The result is very significant for it limits the progress of the housing programme, and to some extent the expansion of electrification and telephones and the speed of railway travel, whilst the general scarcity causes delay or abandonment of plans of many kinds. There are no signs of a significant relaxation of this position for some years to come; on the contrary, if the forecasted rise in timber prices materialises there will be all the greater need to restrict imports.

But some will ask how planting at the moment will ease the situation if, as is often alleged, the trees will not become productive for something like 50 years. By now it ought to be more widely known that this legend is false. With some of the quick-growing species planted under favourable conditions and properly managed it is frequently possible to thin and produce marketable material from plantations of only 15 years of age, sometimes even earlier. True little of this is large enough for sawing into building and similar categories but the pitwood produced in the early stages can take the place of imported pitwood and reduce the annual bill of over £20 millions which it is now costing, leaving more money for importing larger sizes. The production of saw timber also is much quicker than some imagine; there are instances of timber being used for building having been cut from trees not more than 20 years of age and it is generally pronounced to be equal in quality to much that is imported. It follows that the planting done now will soon lead to a strengthening of our economy but, in any case, the sooner a start is made the sooner will those benefits be forthcoming, and from all standpoints the need is great.

The other criticism of forestry is that every acre of land taken for afforestation reduces food production and this is not the time to do anything which causes that to happen. Admittedly sheep will be displaced because trees and sheep cannot occupy the same ground but, since there is not and never was any intention of planting good agricultural land and the agricultural authorities also ban cattle land, no food other than mutton is affected. Even in regard to sheep the position is not so black as it is sometimes painted. On the basis of plantings to date it is estimated that the afforestation of 1 million acres would only reduce the production of homegrown mutton by 2·2 per cent. (2) with present sheep stocks and present standards of food production. However it is highly questionable if sheep stocks are sensibly reduced by forestry. In Wales, for instance, although 150,000 acres of new plantations have been formed since 1920 the sheep stocks have actually increased during that time from 3,331,123 to 4,235,181 head in 1952, despite the heavy losses caused by the severe winter of 1947. A similar position is found in Argyllshire, where the area of Commission plantations is now 57,000 acres, the sheep stocks having increased from 480,772 in 1930 to 503,189 head in 1952 and there is no doubt that much the same sort of thing has occurred in other hill districts. On the other hand agriculturists claim that it would be possible to increase production significantly if the proper measures were taken. Seeing that the vast bulk of sheep pastures lack drainage—although some improvement is now beginning to take place—and also lack lime and phosphates it is very understandable that a relatively small amount of simple treatment would effect a considerable improvement in productivity, much greater indeed than the theoretical reduction of 2·2 per cent. of mutton per million acres planted.

The 50 years' programme was based upon such considerations as these. The White Paper assumed that the bulk of the new afforestation of 3 million acres would be carried out by the State and we will

now briefly consider how and whether it can be achieved.

Firstly as to land and its availability. Accepting that good agricultural land will not be planted it is clear that the bulk of the land must come from the category classified as ' Poor quality mountain and moorland ' which is generally known as ' Rough Grazing.' Perhaps naturally, there is some resistance to a substantial portion of it passing over to forestry and if it were fully productive the objection might be sustainable. But the Report of the Committee on Hill Sheep Farming in England and Wales, 1944, shows that it is by no means fully productive since it refers to ' the present plight of hill farming . . . The cumulative effect . . . is a state of widespread dilapidation.' From another source (3) one learns that the quantity of food produced by hill land is unbelievably small, for instance the average production of hill farms of Wales is stated to be 6·4 lb. of mutton per acre per year and when other forms of food production are equated in terms of mutton the total food production is equivalent to 9 lb. of mutton per acre per annum. Moreover much of this land is covered with bracken and it gets worse in many parts of the country. The Development Commission (4) states ' it was estimated in 1941 that over ½ million acres of land in Scotland had been rendered unfit for grazing by encroachment of bracken and, at that time, the acreage was steadily increasing.' To foresters it is scarcely necessary to point out that bracken land is one of the most highly productive timber-growing sites and yields some of the best financial results under timber. What is more important these days, there appears to be little attempt at improvement despite government offers of assistance, for official figures show that in mid-Wales only 6 per cent. of the eligible farms are actively participating in Hill Farm Improvement Schemes and this figure is said to be fairly representative of the country. The ' Rough Grazing ' covers two-thirds of Scotland, one-third of Wales and large areas in England, and totals nearly 18 million acres. Of this the Chief Adviser on Rural Land Use to the Minister of Agriculture and Fisheries says, ' This is the problem land of Britain. . . . Little use can be made of tracts with frequent rock out-crops, except to leave them as they are or possibly to attempt afforestation. On some hillsides there is evidence of attempted cultivation in times past and probably about one-third of the whole could be improved to good grazing by disc ploughing, seeding and rolling. Another third is suitable for afforestation, leaving the remainder much as at present ' (5). At a later stage Dr. Stamp maintains the same proportion in his forecast of ' Possible Changes in Land Use in Great Britain ' and arrives at 9 million acres as the New Acreage of Forest and Woodland which, with the existing 3 million acres of woods, implies 6 million acres of new forest. With such independent testimony one need not question that the land for afforestation exists ; one can compare this figure with the 5 million acres of forest forming the basis of the Commission's programme and to remark that, within the 18 million acres of rough grazing, fully the 3 million acres of bare land required are suitable for planting from the technical forestry point of view.

The bulk of this land is privately owned and will need to be acquired by the State. Between the wars acquisition was relatively speedy and the Commission was able to accumulate the land reserve which was found to be necessary for an expanding programme. For a multitude of reasons increased difficulties of acquisition are experienced and although it has been possible to reduce the size of land reserve relative to planting programme, progress in carrying out the programme is seriously threatened. This factor indeed is at the moment the most serious cause of delay, more important even than difficulties of money, labour, staff, materials or anything else. Were it not for shortages of land much more headway could be made ; as things are, since the war the area planted in one season has increased from 10,488 acres in 1946 to 68,000 acres in 1953. The last figure is the highest on record and it is planned to plant an even larger area in 1954, so that if the Commission were given its head it could achieve its part of the programme.

In past years the bulk of the forestry in this country was carried out by private landowners. Although under changed

conditions the State is bound to take the dominant part in future forestry plans the Commissioners' policy is to encourage private owners to continue to take as large a part as possible and specific provision is made for this in the White Paper programme. In spite of many difficulties the area planted or replanted privately increased from 5,300 acres in 1946 to 15,100 acres in 1952. The replantings have remained static at about that area for three years. The Dedication Scheme has not flourished because of unforeseen drawbacks and the fall in home timber prices is again said to be discouraging owners. At the moment it is not clear how the private side of the forestry industry will develop but the 1 million acres of devastated old woodlands must be brought again into production and from all points of view it is desirable that this should be done by private agencies. The alternative is for the State to do the replanting and this would mean that ownership of the land would pass to the State either by purchase or by lease. Experience of the Woodland Surveys in Wales show that when the facts are put clearly to the owners a large proportion elect to do the work themselves provided the lack of knowledge, labour and supervision can be overcome. When this provision is made or is in prospect through the agency of Woodland Societies working on a co-operative basis a considerable impetus is given to private forestry, private owners electing to retain and replant more than half the area affected. At the moment there is no better evidence than this and it is based upon a substantial area representing about one-sixth of the woodlands of Wales. Replanting since the war has been done in almost equal proportions by the private owners and the Commission and if the two indicators are taken in conjunction it seems reasonable to conclude that private forestry will bear a fair share of the total programme. Nor need this be confined to replanting and management of existing woodlands. Present-day taxation and other conditions suggest that forestry should be a profitable investment for wealthy landowners. The late Duke of Westminster appreciated this and in different parts of the country he embarked upon considerable forestry schemes which immediately benefited those districts by increased employment, the improvement of dwellings and the erection of new houses. Altogether private landowners can make a welcome contribution both to the increased supply of timber and the rehabilitation of the countryside.

A serious delay in carrying out the programme would be detrimental to the country's economy in more senses than the loss of timber production and a corresponding saving in imports. It would also mean that the supplementary benefits of forestry would not be realised to the desired extent and they are claimed to be of considerable economic and sociological value ; of those the more striking are employment with its effect upon rural population, improved land use and the advantage to agriculture.

Employment in forestry is now given to some 20,000 persons of whom 13,000 are employed in the state forests. These forests are in their early stage of development and the rate of employment, 1 man per 70 acres, is only a beginning, yet already they employ about three times as many men as were formerly required on the same land under hill farming. When the thinning stage is reached the rate of employment increases but even at the present rate the completed programme will require 65,000 workers for direct work in the forest.

As yet we have little experience of the requirements of mature forests because there are few in the country and they are relatively small. But wherever the older ones exist there is sufficient evidence to show that at home and abroad forests lead to the establishment of various industries within their reach. The development of the furniture industry at High Wycombe, which was based in the first instance on the Beech woods of the Chilterns, is one of the shining examples but the presence of sawmills, turnery works and other wood-working industries near any forest is sufficient to indicate the possibilities when our forests are properly established.

There is a divergence of opinion amongst industrialists as to whether it is preferable to locate timber using industries near the source of the raw material or whether it is more advantageous to

transport it to and work it up in a populous district near to the centre of consumption. Whatever the general feeling may be there are bound to be some who will be attracted to the former practice and it is certain that this must be encouraged for the welfare of the forest. For unless light industries can be installed which will provide work for women as well as men it will not be possible to retain a flourishing community and the labour for the forests will not be forthcoming. On these grounds it is reasonable to expect that industries will be established in the neighbourhood of forests and the communities envisaged for the formative and early life of the forests will be supplemented by the needs of those industries. What these needs will be remains to be seen but continental experience shows that for every man employed direct in the forest three more are required for ancillary industries.

In any case the additional labour required by forestry will be very considerable and, as a substantial proportion must be housed near the forests, this should effect an impressive change in districts where there is much concern over rural depopulation. This is occurring at varied rates in different types of country but it is clear that depopulation is proceeding most rapidly in the hill country. For example the recently published statistics for an area of about 750,000 acres in mid-Wales (6) show that this rural area has lost 16 per cent. of its population since 1911. Although this loss may be exceptional there is evidence that something similar is happening in many other hill districts where generally housing is poor, services are almost non-existent, and in modern times people will not accept such a low standard of living. This is particularly important to the sheep-grazing industry, for shepherds are getting scarcer and very difficult to obtain whilst young men are not entering the industry in sufficient numbers to make good the loss of ageing farmers. In many districts farms are becoming derelict in increasing numbers and the only remedy—a partial one—so far is the amalgamation of farms for ranching, which agricultural authorities deplore. Naturally a reduction of the population accompanies this process and the only hope of arresting it is some fundamental change which will provide work and decent living conditions. Fortunately this is precisely the type of country which is suitable for afforestation. There is virtually no unemployment in these areas, consequently a high proportion of the labour required for forestry will have to be introduced. In turn this will mean more houses in rural areas since the labour must be within reasonable distance of their work and the houses do not exist in sufficient numbers to-day. If these houses were built in communities, as would be both convenient and preferable if forestry were proceeding on a large enough scale, it would justify the provision of services and social facilities which would attract workers, with their wives and families, and encourage them to remain. It is not difficult to imagine what the effect would be on the countryside.

Farmers in the locality would be the first to benefit. There would be an increased market for dairy and other farm produce on their doorstep and they would find a handy source of supply of many of the classes of timber which are essential to the farm. Assuming a wise allocation of land for forestry, the shelter afforded by the forests would lead to increased productivity on the neighbouring farms due largely, it is hoped, to the increase of cattle. There would be ample opportunities for farmers to increase their earnings by haulage which the formation of forests and later extraction demand on a substantial scale. The arrangements for supplementing labour from the forest staff at such special seasons as haytime and harvest are proving a useful standby to farmers and these would naturally be extended as forests enter wider districts, whilst they could well cover other seasons or operations such as shearing, as in fact is happening in at least one Woodland Society's territory. In these and other possible directions forestry would be of advantage to farmers, and one must not overlook that the newly introduced or improved social facilities for the community would also be available to them and other local residents.

Tradesmen of all kinds, whether existing or newly introduced, would experience a steady custom which would derive from a community in receipt of a regular pay

packet of no mean order. Take the existing example of a newly formed forest of 9,000 acres in a neighbourhood where the only town within miles is one of fewer than 2,500 inhabitants and the yearly wages of the forest workers amounts to £43,000. Here, as elsewhere, forestry is taking spending power to the rural districts, which is what they require more than anything else if those districts are to be rehabilitated. Imagine the effect upon the countryside if this were repeated in many more places; local tradesmen have no illusions as to its value and, inspired by this and other examples, there is a growing demand for the extension of forestry to other hill districts.

In these days of stringency surely it is essential to use all our resources to the best advantage. Land is the basis of all wealth and yet, as the views quoted above suggest, a considerable section of the country is not utilised to the full. This is agreed by many agriculturists, indeed many go so far as to say that it will not be economic to embark upon the improvement of large areas of poor land which has been called the problem land of Britain. Since the present production of 9 lb. of mutton per acre per annum can be converted to 2 or 3 tons or more of timber per acre per annum and at the same time depopulation can be arrested the forester does not regard it as problem land, the only problem being to obtain possession of large enough tracts for afforestation.

The value of forestry to water undertakings is summed up in the following terms (7):

'Water undertakers have expressed themselves in favour of afforestation for the following reasons:

for the productive use of land which would otherwise be idle;
as a barrier against the public and cattle round the verges of reservoirs and sometimes along feeder streams;
as a natural filter for holding up silt and removing pollution from surface run-off, especially in heavy rains;
as a 'sponge' to even out the flow from varying rainfall;
as a wind break.'

The planting of water catchments is proceeding steadily but there is a considerable portion of the estimated 425,000 acres without any plans for afforestation. One is encouraged to hope that, with this independent and authoritative testimony in front of them, the outstanding water authorities will adopt forestry as a profitable and public spirited method of utilising their gathering grounds, especially as it would affect food production to the minimum extent.

The question of improved amenities is hotly debated on the grounds of conifers versus hardwoods, but it is believed that the two sides are about equally balanced although the objectors to conifers appear to be the more vocal. It is observed that many people enjoy holidays in Switzerland, the Black Forest, Austria and other places where conifers form a dominant part in the landscape, that Deeside with its fine old Scots Pine is a favourite centre and it is not doubted that when our new conifer forests become more mature they will increasingly become sources of attraction and lead to extensions of the tourist industry.

To sum up, our home supplies of timber are sadly depleted, for economic reasons we could not import all our requirements even if they were available and a considerable shortage of supplies from overseas is anticipated for many years. Our country is well suited to the rapid production of good quality timber and there is a large area of land at home which is suitable for timber growing but under present conditions is neither fully productive nor has any prospects of becoming so. The country's economy would be greatly benefited by the extension of forestry which, apart from the production of timber, would arrest depopulation in and confer other signal benefits upon rural districts where the forests were located.

This can be achieved with an insignificant interference with food production; on the contrary if properly sited the forests would provide shelter and, coupled with the introduction of more cattle which would then be possible, there might be no loss at all.

We must visualise a forestry industry as one entity, not as two independent units of State forestry and private forestry, but one industry which is managed partly by the State and partly privately. This is

inherent in the Commission's programme which postulates that the objective of 5 million acres of well-managed forest will be made up of a private contribution and a State contribution. In turn it assumes that between the two managements there must be the closest possible association and collaboration. One sees the foundations now being laid for this ideal with the advent of Dedication, the formation of Woodland Co-operative Societies, the provision of technical advice and the closer association which has been established since the war in negotiating the sales of pitprops of both State and private production.

One envisages that there will be forests of two kinds : (*a*) large ones to justify roads, for the maximum production of high quality timber, etc., which will be mainly State but occasionally private also ; (*b*) smaller ones made up of groups of smaller size, including private woodlands and shelter woods.

If forestry takes its rightful place in our economy I foresee tracts of hill country with the good land in the valleys and some of the not so good land under agriculture, carrying more cattle than we are wont to see, the middle hills and steep valley sides covered with forest whilst the upper slopes and mountain tops remain as they are, providing grazing for sheep. Existing villages will be extended and other new ones will spring up at intervals, all with improved services and social amenities and better road systems with buses communicating with the nearest market towns. Within the villages will be mixed populations with employment in the forests and local industries based on timber as well as other local industries. In the lower country derelict woods will be replaced by flourishing plantations giving their meed of employment, in local industries timber will figure more prominently as a raw material and shelter woods and belts and plantations on odd patches of former waste ground will be a common feature of the landscape.

A rosy picture you think ? I agree it is, nevertheless foresters are convinced they can achieve it if given the opportunity. Foresters disclaim any desire to impinge upon agriculture proper ; on the contrary, as countrymen we hope to see its position strengthened not only for increased food production in general but also locally near the forests because dairy and farm produce are essential for forest workers. We claim that with proper treatment there is ample room for both.

There is no question that forestry must and will expand in Britain. The requisites are there : the need is economic, materialistic, sociological and for defence ; the land is there ; the foundations of a Forest Service have been laid to do the work and it has the will to carry it out. If the expansion of forestry *can* produce the beneficial changes, of which some have been mentioned, as it undoubtedly can, who amongst us will deny that Forestry ought and must take a more prominent place in Britain's economy ?

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THE USES OF LABORATORY ANIMALS IN GREAT BRITAIN[1]

by

DR. W. LANE-PETTER

IT is a great privilege for me to be allowed to address you here to-day upon a subject which is, or should be, of personal interest to every one of us.

Recently, on one of the most impressive occasions of contemporary history likely to occur in our lifetime, there was included in the Coronation broadcast an appeal to make sure that while we rejoiced our domestic animals did not suffer. A nation that can do this obviously has a high sense of responsibility towards the brute creation, as another Queen described the lower animals.

DEFINITION OF A LABORATORY ANIMAL

It is always well, when embarking upon a discussion, to define the subject under consideration, but this is sometimes less simple than it appears. Most biological scientists have a clear idea in their minds of what is meant by the term laboratory animal, but in each case they will be thinking chiefly of the animals they have to do with in the course of their own work. How far down the animal kingdom should one go? Is the plasmodium of malaria used in *in vitro* tests for plasmodicidal drugs a laboratory animal? Should the definition cover sheep undergoing controlled observations in the field, rather than in the laboratory? Is the pharmacologist experimenting upon himself to be included? It does not really matter which way the questions are answered. The conception underlying the term laboratory animal is more easily understood if one adopts a pragmatic approach.

In the course of scientific investigation it is very often inconvenient or impossible to make a sufficiently detailed examination on the original subject, and this applies particularly in the field of medical and allied research. Here the original is usually man, and this fact automatically imposes an ethical bar on the permissible extent of direct observations, for in a civilised community the life and health of the individual must remain unassailably sacred. So it happens that many observations, notably those involving risk to life and health, must be made on substitutes, and for convenience lower mammals are most often chosen for the purpose. But this introduces a second ethical consideration.

In an experiment devoid of hazard to life or health the subject may, by his own individual consent, be man, and if consent has been given for the infliction of pain in the course of the experiment there is no offence. But lower animals cannot give consent, and it is repugnant to most people to subject unconsenting creatures to more than a certain degree of suffering. Where the line is to be drawn will depend on time, place and community. Harvey's experiments on living unanaesthetised dogs would to-day arouse great indignation, and rightly, although it cannot be argued from this that Harvey was an insensitive person. In fact, he was the reverse; but in his day, when a hungry child might be hanged for stealing a loaf of bread, when torture was considered a proper method of legal inquisition, and human surgery was an ordeal of like severity, the sufferings of a few dogs were considered a small price to pay for the discovery of the blood circulation. To-day our standards are different, and we recognise that the animals, too, have rights. It is permissible to kill, but not to inflict pain for any reason beyond a certain limit, and not at all without good

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cause. It is also permissible to breed animals deliberately for human use, whether for food, work, entertainment, or scientific purposes, and the species which have proved amenable to domestication for any of these purposes may be regarded as having achieved a measure of evolutionary success, in that by making themselves useful to man, the biggest predator of all, they have ensured their continued survival. The wild brown rat, by competing with man for man's food, has provoked a declaration of interspecific war which must in time end with the rat's extermination; but his species will continue as the albino or as the hooded rat in the laboratory long after the wild type is gone.

We come, therefore, to a clear idea of what a laboratory animal is, in a practical rather than a philosophical sense. It is a sentient animal (or so presumed) used in scientific work, partly or wholly in laboratories, and bred or kept in the main for that purpose. The price it pays for this favoured position in relation to man is to be subjected to procedures the painfulness of which is limited by ethical considerations; and in many cases to curtailment of the normal life span.

Historical

The history of the use of experimental animals goes back to some indefinite period in the past, at least as far as Galen in the second century, while the idea of 'trying it on the dog' antedates civilisation itself. Although the seventeenth century saw the beginning of modern scientific inquiry, another 200 years elapsed before experimental physiology came to be recognised as the keystone of biological, and especially medical, investigation; and the awakening of public consciousness of animal experiments owed not a little to the discovery of anaesthetics in the middle of the last century.

By a curious coincidence the first formal steps towards imposing control over animal experiments in this country were taken when Section D (then Biology) of the British Association for the Advancement of Science at its Liverpool meeting in 1870 instructed a committee to consider the question of pain in relation to experiments. This committee reported back the following year with certain recommendations.

In 1875 a Royal Commission was appointed, and the following year the first and only Act of Parliament covering such experiments was passed. There is in the *U.F.A.W. Handbook on The Care and Management of Laboratory Animals* an excellent summary of the stormy controversy of those days, and I do not propose to say more about it, beyond pointing out that the subject is no longer in any real sense controversial, in spite of the activities of a group of irreconcilable opponents of all animal experimentation. If prejudice and emotion are put on one side, then it must be recognised, as indeed it has been in every public inquiry, that on the one hand this method of investigation has provided knowledge contributing to the welfare of mankind, as well as of animals, which could not have been produced in any other way, or if it could, then not over a comparable period; and that the legal safeguards provided in the Act of 1876 have, with the goodwill of all responsible scientists, succeeded in preventing those abuses of animals which many intelligent people at one time feared.

It is salutary for the cynic, and comforting for all of us, to realise that the collapse of the great vivisection controversy of the nineteenth century, which disturbed Queen Victoria herself, is an example of truth triumphing over misrepresentation.

Laboratory Animals

Over the last seventy-seven years when records have been available the number of experiments carried out in Great Britain under the Act of 1876, which roughly corresponds with the number of animals used for scientific purposes, has risen from a few hundreds to very many thousands a year. To-day the figure stands at about two million.

Now, this is a very large number, and the expectation is that in years to come it will grow larger. But if it is related, as it should be, to the extent of our present day medical and veterinary services, to the increasing measure of scientific control being exercised over our food and our drugs, and to the volume of research, in all of which activities the animal has contributed so remarkably, then the figure is seen in its proper perspective.

Three main questions spring to the

mind. What sort of animals are those two million? What are they used for? What exactly happens to them? Three further questions follow. Where do they come from? How are they cared for? What legal control is there over their use?

To begin with, 75 to 80 per cent. of these animals are mice, mostly white mice, and all of them specially bred for the purpose. Guinea pigs and rats together account for about another 14 per cent. The remainder are rabbits, dogs, cats, monkeys, ferrets, birds, amphibia, horses and many other species. Well under 1 per cent. of all experiments are carried out on dogs, cats, monkeys and horses put together. Thus the small rodent, and, above all, the mouse, is enormously in the majority, but it must be added that for certain purposes other animals are more suitable, indeed indispensable. This applies particularly to cats and dogs, whose very domestication by man for other purposes makes them the species of choice in particular cases.

Uses

What is this zoological array used for in laboratories? Briefly, for research and teaching on the one hand, and on the other for what may be called applied medicine. Most workers in medical and veterinary science, and many in the biological field, though not strictly medical, must from time to time in their researches appeal to the living reagent. The whole structure of medical science, since it became a science but more especially in recent years, rests in part on this method. It is indeed hard to see how the study of natural events in living organisms can proceed without detailed study of these organisms or their near relations. So it is perhaps more accurate to say that the study of animals in health and disease, normal or abnormal, and especially when the second alternatives are experimentally and therefore controllably induced, is not so much a method as *an integral part of medical research*, and must always remain so.

Physiology in the broad sense is the study of the normal working of living organisms. In studying various aspects of the normal, it may be necessary to separate them as far as possible from the rest, and this may involve dealing with an organ by itself, such as a nerve muscle preparation, or an isolated heart, lung or liver. This can only be obtained from a living animal, or rather from one which is killed immediately before the removal of the organ or tissue under investigation; it cannot be classed as an experiment on a living animal. Next up the scale, so to speak, is the use of an animal, intact except for the extirpation of all or a major portion of the central nervous system; pithed and decerebrate animals are good examples of this. Such an animal, though it breathes automatically and its heart beats for some hours, is not in the ordinary sense alive; it has no subjective sensation and no power to make any but automatic and reflex movements. Still further up the scale is the living animal from which some organ or tissue has been removed, or which has undergone some surgical interference under anaesthesia. In many experiments the animal remains under the anaesthetic throughout the whole experiment and never recovers. Sometimes, however, it is allowed to recover for the sake of subsequent observations over a period of hours, days, weeks and occasionally longer.

All these experiments, in the main physiological, involve more or less extensive surgical procedures—vivisection if you like—but with due regard to the use of anaesthetics. They have a singular appeal to lurid imaginations, and they represent only a small minority of the total of animal experiments.

Turning to the study of the abnormal, represented by pathology and its allied disciplines, the pattern frequently followed is to study in an otherwise healthy animal a known type and degree of morbidity deliberately induced; a morbidity due to infection, to the administration of toxic substances, to the withholding of an essential component of the diet, or to some organ or tissue abnormality. Exposure to abnormal physical conditions—thermal, atmospheric or electrical—is yet another type of experiment which is perhaps more in the physiological field than the pathological. Such experiments have often to be kept going for days or weeks, and occasionally longer, so that the animal may have time to develop the abnormal condition which is the subject of study.

In all these cases the animal is an essential reagent in the search for further knowledge, a tool of the research worker ; or in limited instances a subject for teaching or demonstration to new generations of students. There is, however, no sharp dividing line between this and the field of applied medicine, which I have already referred to.

The investigation of new drugs, prophylactics, or other therapeutic substances likely to be of use to man or animals will at some stage or other almost invariably necessitate appeal to the animal—or rather to many animals—and as such substances are continually being produced, their testing makes a constant call on laboratory animals. The same applies to the standardisation or assay of many substances of proved value, such as specific antisera, digitalis, insulin, and a host of others. Bioassays involve statistical methods, which in turn demand numbers of animals, and this sort of work accounts for the greatest number of animal experiments. Economy and convenience point to a small animal, and this is the main field of mouse consumption, leading to the great numerical preponderance of mice among the total of experimental animals. At the same time, where large amounts of specific sera are required, such as tetanus or diphtheria antitoxin, both of inestimable value to mankind, the largest convenient animal is chosen, namely the horse.

A detailed analysis of the numbers of each species used for different purposes is not available, although an investigation is at this moment being carried out. The following approximate percentages may, however, be of interest.

Of the total of all animal experiments carried out in this country, some 10 per cent. are for the diagnosis of disease in man and animals : these are for the most part guinea pigs, but include a number of mice and other species. Something over 50 per cent. are for the purpose of biological assay of sera, prophylactics, and some drugs which cannot be estimated by other means ; these are usually mice, but also include rats, guinea pigs, chicks, and other species. The screening of new compounds of possible therapeutic use accounts for a further 20 per cent. : again, mostly mice. The remaining 20 per cent. are used for a large variety of purposes in the various fields of research, including 5 per cent. of the total in the course of cancer investigations.

Experimental Procedures

The term vivisection suggests that it involves the cutting up of live animals. Nothing could be farther from the truth, and although it is used to cover all experiments on living animals, most experiments involve no cutting whatsoever. The very word vivisection is grossly misleading ; it is much more accurately applicable to the castration of farm animals, which is still, or rather was until very recently, for the most part carried out up and down the land without anaesthetics by people with no scientific or veterinary qualifications and in the absence of any sort of legal control ; to the sticking of pigs not previously stunned ; or even to the docking of tails for cosmetic and other reasons. But the scientist is much more strictly bound by law than the farmer, the sportsman, the trapper, or the gamekeeper as to the amount of pain he may inflict on animals for any reason whatsoever, a discrimination against him of which he does not much complain ; and the law is strictly enforced by a system of inspectorate by the Home Office. I will have more to say about this later. The majority of laboratory animals used undergo procedures, such as hypodermic injection, so trivial that to administer an anaesthetic would be a greater discomfort. The effect of such minor procedures may in some instances affect the animal in a painful way, such as the induction of a disease process, but this is not always, or even usually, the outcome, because more often than not the animal is killed before it becomes seriously ill. Guinea pigs are chiefly used in the diagnosis of tuberculosis in man or cattle ; the suspected milk or other substances is inoculated into the animal, which is killed some two months later, long before the disease is able to produce any effect at all, except at *post mortem* examination. In other cases mice, for example, are injected with substances to test their toxicity or measure their protective effect against disease ; often nothing happens at all, but if it does, the

onset of symptoms is nearly always the signal for the painless destruction of the animal and the conclusion of the experiment. In still further cases, rats, for instance, may be fed on a special diet lacking some essential ingredient, and thus develop signs of a deficiency disease. In this way our knowledge of vitamins and other nutritional factors has been built up, and is being constantly added to.

In the minority of experiments where more severe procedures are necessary, anaesthetics are invariably given, and if the animal is allowed to recover from the anaesthetic, the same sort of care is taken of it as is given to a patient in hospital. In fact the practice of experimental surgery of this kind has to-day reached a very high level of proficiency. Such operations include the removal of one or more of the glands of internal secretion or other organs ; the creation of alimentary and other fistulae ; the alteration of position or distribution of blood vessels ; the cutting of nerves or other structures ; the implantation of organs or tissues ; and, rarely, the production of traumatic conditions of one kind or another. (In parenthesis it may be added that the details of every surgical interference of this nature are governed specifically by existing legislation and practice.)

Pain, then, is not a prominent or even a constant feature of animal experiments. It is an undesirable accident in some cases, avoided for scientific and humanitarian reasons as far as possible.

Now this begs a question. How do we know whether or not an animal is suffering pain, and if so, how much? Of course, one can only *know* how much pain is being suffered by *oneself* ; pain in another person can only be recognised and assessed by the verbal or other evidence provided by that person. The question is even more difficult in the case of animals, for they cannot give verbal evidence. But, in the light of our own experiences of pain, and our observations of others, we have learnt to associate certain procedures with pain, and certain behaviour reactions with its manifestation ; and we can in many cases even predict, from our knowledge of anatomy and physiology, whether or not certain procedures are likely to be painful. And, lastly, we know a great deal about anaesthesia, both general and local, and can recognise and control its depth and extent.

As long ago as 1882, it was estimated that 75 per cent. of all so-called vivisections were absolutely painless, and a further 20 per cent. were no more painful than vaccination. The remaining 5 per cent. were no more painful than a surgical operation under anaesthesia together with the ensuing post-operative discomfort. To-day the picture is not greatly different. From the animals' point of view the pain resulting from animal experiments is often absent, usually trivial, sometimes moderate but shortlived, occasionally severe but then always transient, and never extreme in either severity or duration.

Sources

It is not the purpose of this paper to examine in detail the sources of laboratory animals, but it should be pointed out that by far the greater number are specially bred for the purpose. They may be bred in the laboratory in which they are to be used, or in another laboratory ; or on a breeding farm run commercially but disposing of all or nearly all its output to laboratories either directly or through a dealer. Some, however, may be collected from the wild or quasi-wild state ; for example, those species, notably frogs and toads, monkeys, and dogs and cats, which it would be impossible, inconvenient or uneconomic to breed specially.

The commercial breeders of animals such as guinea pigs, mice and rabbits are for the most part in a small way of business. They breed these animals because they are interested in them ; indeed, many of them are, or have been, keen fanciers. Very often it is a part-time or spare-time occupation, for the profits are small, and the commercial risks considerable. They are in the main skilful and knowledgeable people, and will sometimes admit to a certain pride in contributing in this way to the furtherance of medical research. They provide rather over half the mice, nearly two-thirds of the guinea pigs, and perhaps a like proportion of rabbits used in laboratories throughout the country, the remainder being bred in the laboratories themselves.

The collector and the importer are in a different category, but they too have their place in the supply of animals. The collectors or animal dealers are the link between the very small, usually seasonal, breeders and the laboratories. Their contribution to the total supply has been included in the estimates just mentioned.

Monkeys, some amphibia, and small numbers of certain other species come from overseas, in particular India and Africa. They normally come by air, and on the whole they travel well.

A special point arises in connection with cats and dogs. A small number of these animals are bred in laboratories, but at great expense, while many times the number required for scientific purposes are destroyed because they are homeless, ownerless and unwanted. There is a long-standing shortage of these two species throughout the country which is a serious embarrassment to research, teaching and other work. Most of the dogs and cats that are supplied to laboratories come from dealers, who often have considerable difficulty in obtaining supplies, and this means that the expense of acquiring these animals is artificially inflated. The situation has an element of grim irony in it, like paying dollars for coal while there is more than enough in this country for the digging. It could be corrected almost overnight if a small proportion of the vast number destroyed in any large urban area were made available to the laboratories ; and these need never include any animals whose owners objected for any reason at all, for most of those now killed have no owner. In the Metropolitan Police area alone some 20,000 unwanted dogs are destroyed annually, while over the country as a whole it is estimated that in a like period some 200,000 cats meet the same fate. A small fraction of these surplus animals would meet the needs of every laboratory in the country. While laboratories have to depend on private traders it is perhaps theoretically possible, in spite of the extreme vigilance of the laboratories, for a genuine pet, after passing through more than one pair of hands, to be offered to a laboratory. If those who to-day slaughter these large numbers of unwanted animals were to offer a small proportion of them to science, this private trade would cease abruptly, and no one would be more pleased than the scientists.

Care

Laboratory animals are the tool of the experimental biologist ; they are living reagents, valuable and indeed indispensable. It follows that they must be well looked after. The care of laboratory animals has of recent years attracted particular attention on the part of scientists, and their breeding, feeding, housing, and general management have been the subject of much care and research, and many publications. Perhaps the first requirement is that they should as far as possible be free from disease, at least of such infections as experience has shown to be the cause of serious losses or of interference with experimental work. They must be housed and confined in conditions compatible with health and comfort, for in use they require to be handled, and a well cared for and contented animal is likely to be more tractable than one in which these conditions do not obtain. And in many cases they must be of known and constant strain or pedigree. But above all these practical considerations, which are directed towards providing the experimentalist with a satisfactory reagent, is the conception of a duty towards the animals themselves.

Modern laboratory animal husbandry seeks to fulfil these requirements by means of good houses, well designed cages, complete diets, a very high standard of hygiene and expert attention by trained technicians, and it is probably true to say that to-day the animal house absorbs a greater proportion of the total financial budget of a laboratory than ever before. Those who use animals in their work do not need to be reminded that money is well spent in this way, but it may sometimes be a little difficult to persuade a university senate or a hospital management committee that this is so, when there are more familiar rival claims on expenditure.

It is not necessary to labour the practical utility of animal experiments, and I have already referred to the evolutionary advantage belonging to any domesticated species. But the proper care of laboratory animals does more than provide the experi-

mentalist with good material, although that is itself essential. There is something deeply satisfying about a group of animals kept under really good conditions, in a state of health, nutrition and comfort which they would be unlikely to enjoy in nature. A herd of dairy cattle, or a colony of guinea pigs, is justified, given meaning, by its utility, but contributes something more than utility to the fullness of existence. I think that those who have to do constantly with animals, including laboratory animals, will more readily appreciate this.

Legal Control

It is reasonable at this stage to inquire into what legal control exists in this country over the use of animals for scientific purposes.

I have referred already to the Cruelty to Animals Act of 1876 (to give it its formal title) which followed the report of the first Royal Commission on Vivisection. This Act provided that experiments be carried out on living animals only for *bona fide* scientific purposes, and it covered experiments on vertebrate animals 'calculated to cause pain.' As has been pointed out, much that is undergone by laboratory animals is no more calculated to cause pain than the details of farm husbandry, and is in no degree objectionable, but because it may be thought to interfere with the general comfort of the animal it is held to come under this Act. Then the Act lays down somewhat elaborately the conditions under which anaesthetics must be used or may be dispensed with, although anything done to an anaesthetised animal cannot, by definition, be calculated to cause pain—the animal is in a subjectively insentient state, at least while the anaesthetic lasts. Then such experiments must be carried out in a laboratory registered by the Home Office —there are a very few unimportant exceptions to this rule, over which the Home Office keeps especially strict control—and the person conducting the experiment must hold personal authority, in the form of licence and certificates granted at the discretion of the Home Office. And on top of this, the Home Office employs inspectors who pay visits, usually unannounced, to the various registered laboratories, and whose business it is to make themselves acquainted with the work being done there, and the licensees with the full extent of their obligations under the Act. With happy forethought the Act empowers the Home Secretary to attach such other conditions to licence or certificates as will further the purpose of the Act, which is to give adequate protection to experimental animals and to the public conscience without impeding legitimate scientific work. In fact, full advantage is taken of this provision, and certain conditions apply in every case, the most fundamental of which states as precisely as can be stated the amount of suffering considered permissible in any case for whatever purpose.

There can seldom have been any Act on the statute book the honest administration of which has been more bitterly and continuously assailed. Thirty years after its enactment, a second Royal Commission began to examine its operation in the light of many savage attacks ; it sat for six years, asked 21,761 questions of fifty-eight witnesses, and came to the conclusion that the Act had been applied as it was intended ; that licensees ' with rare exceptions ' had conformed to its provisions, and that the evidence submitted to the contrary was inaccurate ; and that animal experiments had led to valuable knowledge of benefit to mankind and animals, and that similar methods of investigation if pursued in the future would be attended with similar results. (R.C. on Vivisection, para. 75 (5).) That was in 1912. Insulin was discovered in 1922 : sulphonamides in 1935 and onwards : the medical applications of penicillin in 1940 : the list is almost endless. The Commissioners have been amply justified in their prophecy, more so than they could have expected in their most sanguine moments. Repeated attempts to persuade successive Home Secretaries that given instances of published and other work showed disregard of the Act or dereliction of duty on the part of Home Office inspectors have on examination been shown to have no more substance or truth than some of the stories trotted out before the second Royal Commission.

The law does concern itself very seriously

with this matter ; it would be surprising in this country of animal lovers if this were not so. Scientists themselves, like all right minded people, would revolt against cruelty—the wanton or excessive infliction of pain—and are no more likely to indulge in it in the pursuit of knowledge than for any other reason. Nevertheless, the judgment of the matter is not left in their hands, but in the hands of independent persons of standing and fidelity who carry out a difficult task with a competence never yet discredited. The Act does what it set out to do, and despite one or two clumsy administrative points has worked well for over three-quarters of a century.

Conclusion

In conclusion, I would like to quote the words of Philanthropos, the author of a book entitled *Physiological Cruelty*, published in 1883.

> 'The infliction of pain without justification—or with insufficient justification—is cruelty. Sufficient justification consists in the attainment by such infliction of a good which more than counterbalances the evil of the pain given. Long life, activity, and health, are benefits which counterbalance pain even to the same individual ; when the benefits accrue to an individual of a higher class, and the pain falls upon one of a lower, it is still more fully counterbalanced ; when the benefits are to many of the former, and the pain to a few of the latter, the advantage is still further increased ; and when (the other conditions continuing the same) the benefits are permanent, and the pain transient, there can remain no doubt that the justification is sufficient. Such is the case with all experiments which advance physiological knowledge. The longer life, restored health and activity, of an incalculable number of men and women, extending over a considerable time for the individual, and—for the race—over the whole period of its existence, are gained by the endurance for a short time of varying degrees of annoyance, distress, and pain, by a comparatively small number of the lower animals. There is, therefore, no cruelty in the performance of such experiments.'

One should have no quarrel with those who for personal reasons object to animal experiments ; who believe that the earth is flat, and that the sun revolves round it ; who repudiate evolution in favour of special creation ; or who privately wish to adhere to any other of man's passing misconceptions in his painful pursuit of truth ; provided that they do not seek to hamper that pursuit. But if we care for the advance of knowledge and the relief of suffering, let us pay tribute to those whose researches lead us to this end ; and to those who by producing and caring for laboratory animals are contributing their share of effort. And let us remember that man's adoption of certain animals for these purposes, while giving them a favoured position as protected species at the cost—to them—of a strictly limited aggregate of suffering, carries with it an obligation of humanity which we may feel proud to have accepted.

THE LIFE AND TIMES OF SIR RICHARD GREGORY, Bt., F.R.S., 1864–1952[1]

by

Sir Harold Hartley, K.C.V.O., F.R.S.

It was at our meeting last year at Belfast that for the first time for over fifty years we missed the presence of our most constant member, whose friendship and devotion to science, and whose keen mind and sense of humour had given him a unique position as a vitalising and constructive force in the work of the British Association. It is most fitting that this Pedler Lecture, which was his way of commemorating the work of Sir Alexander Pedler as Secretary of the British Science Guild, should be a tribute to the life and work of our old friend Richard Gregory himself.

His life history is a record of successful endeavour that would have delighted the heart of Samuel Smiles as an example of what courage and grit and devotion to science can accomplish. It is a thrilling story of heredity, circumstances, education and opportunity. Gregory was proud of his ancestry and in his study hung a photograph of the inscription to his grandfather, a shoemaker of Bideford :

> He was a consistent member of the
> Wesleyan Society for 65 years,
> And as a local preacher and Class Leader,
> His labours were blessed
> To the Salvation of Many Souls.

John Gregory, his son, followed the same craft but also was one of Nature's poets. I found among Richard's papers this charming letter from H. G. Wells to the old man when Richard had sent him one of his father's slender books of verse in 1907.

> Dear Mr. Gregory, You will I hope forgive my writing to you to tell you how much I like and value your book of poems. Your son has just given it to me and I have been reading in its contents a constantly increasing delight and surprise. He had often told me you wrote verse but he had given me no idea of the simple, curiously straightforward graciousness of your songs. They come I think most appropriately with this spring time ; they have so much in common with the bright freshness of primrose and aubretia and all the daffodils and narcissuses with which the garden is singing. I have been reminded of Blake and Herrick and of all that is most truly English as I read. R. A. G. is one of my earliest friends—I didn't expect at this date to find a quite new reason for liking and respecting him—in such a book as this.
>
> I am myself a sort of literary man though I've never risen to either verse or science. That must be my excuse for bothering you with these praises.
>
> Yours very sincerely,
> H. G. Wells.
>
> The shakiness of the handwriting is not a sudden fit of D.T. But I am writing in a South Eastern train which has just started.

Richard was born in 1864 in Bristol, where his father had moved from Bideford. When he was six he went to the Wesleyan Day School at Baptist Mills, where 300 boys were taught in groups in one large schoolroom heated by a single firegrate. In 1874 he entered the secondary school, now called Queen Elizabeth's Hospital, a boarding school with a uniform rather like Christ's Hospital, where his interest in science began. He left school early owing to his delicate health and began life like Faraday as a newspaper boy, and with his father more interested in poetry than shoemaking, it sometimes happened that his mother could buy no food until Richard returned with his weekly earnings. John Gregory must have

[1] The Alexander Pedler Lecture delivered in the Royal Institution, London on May 28, 1953.

had something in common with Blake and his idealism left its mark on Richard. One of his poems reveals his attitude towards wealth :—

My heaven is not paved with gold ;
For all that has been writ of it,
I would not have it if I could
There's blood on every bit of it.

I would not harm my angel's feet
With such a hateful use of it ;
I loathe, I scorn the thought unsweet,
Because of man's abuse of it.

When Richard was fifteen he was apprenticed to a boot factory for five years to learn the trade of clicking, i.e., cutting out the various shapes of leather that were to be the uppers of boots and shoes. He was unhappy in his work and spent all his spare time attending evening classes in the Bristol Trade and Mining School (now the Merchant Venturers' College) and reading in St. Agnes Club Library.

John Gregory was one of a band of socialist reformers in Bristol actively engaged in establishing the socialist and labour movement. The group included Ben Tillett, Jim O'Grady, later Sir James and High Commissioner in the Commonwealth of Australia. Ramsay Macdonald joined them for a short time in 1884 when he came to Bristol to help with a Boys' Club. At that time he meant to become a science teacher, and when he was Prime Minister he said to Richard, ' You chose the better part.'

Richard and his father were great friends and in those early years he was closely associated with him in his social work. At evening meetings John would give an address on some labour problem or recite some of his poems and Richard would sing or give a talk on a scientific subject, often astronomy in which he was even then keenly interested. John Gregory became a well-known figure in Bristol and in 1912 he was given an Honorary Degree by the University, an honour which Richard was to share with him thirteen years later.

When he was seventeen he won the Latin prize at the Trade School. Canon Wilson, a great educational reformer, who was then Headmaster of Clifton, was an admirer of the personality and poems of Richard's father and often came to see him. He encouraged Richard with his Latin and knowing his wish to leave the factory and learn science, he offered him the vacant post of laboratory assistant at the College. Richard had to secure his release from his indenture and paid an indemnity of £5, which A. M. Worthington, the Physics Master, lent him to be deducted from his first term's wages. One of his congenial duties at the College was the care of the fine 8-inch telescope.

Here at last came the opportunity he had dreamt of during his years at the boot factory and he took full advantage of it, continuing his studies in science and mathematics to such good effect that three years later he gained a scholarship in the Science and Art Department examinations which enabled him to become a science teacher in training at the Royal College of Science, South Kensington. Huxley was then Dean of the College and a new world opened for Gregory. He gained first classes in Astronomy and Physics and two years later, in 1887, he became a science demonstrator in H.M. Dockyard at Portsmouth. His main interest was still astronomy and in 1889 he returned to the Royal College as computor to the Solar Physics Committee and assistant to Norman Lockyer.

At each stage of his life Gregory was fortunate in his friends. At South Kensington he and H. G. Wells were fellow students and they were close companions. Wells has described in *Love and Mr. Lewisham* and in his *Experiments in Auto biography* the aims and hopes and struggles of the students at the College at that time. Forty years later he wrote of Gregory, ' He emerges in my memory as a bland and sturdy figure in the debating society, a little troubled then as ever about the letter " r," friendly, hilarious, hard-up and working hard, one of the cheerful and often quite audible group which includes William Burton, the potter, and A. T. Simmons. We had no relatives to push us on, we had to do all our own pushing, and sometimes the pushing was very hard indeed.

' Gregory pushed his upward course by way of sunspot computation to the stars. He won the respect and confidence of Sir Norman Lockyer. But before his footing was well established there were some

precarious times. I had not so much pushed my way up as out by starting the *Science School Journal* (which is now the *Phoenix*) and similar depravities and my times were even more precarious. We collaborated in a book on *Physiography* (Gregory got the job for me) and earnt £10 each. Ten pounds were worth getting in those days. We lent each other money and returned it (though social observers declare that such returns never happen). We followed our destinies. All sorts of things happened to me but nothing ever changed the steadfast friendship and helpfulness of Gregory.'

Gregory's work with Lockyer was of a routine nature, measuring the areas and positions of sunspots and faculae in photographs taken in 1878–81 at Dehra Dun, Mauritius and Melbourne. He was also concerned in some unproductive work on the widened lines in sunspot spectra and he photographed the spectra of a number of elements. That was his only direct contact with research and his name does not figure in any paper. But Lockyer's work on the orientation of temples in Greece and Egypt appealed to Gregory and was the start of his life long interest in the relations of astronomy and religion.

Soon after he joined Lockyer's staff, Gregory's articles and reviews began to appear in *Nature*. In 1889, ' On the Determination of Masses in Astronomy ' and ' The Planet Uranus ' ; in 1890 on ' Comets of Short Period,' ' Lunar Photography ' and ' Electrical Storms in Pike's Peak.' In the same year he became an Oxford University Extension Lecturer on Astronomy and Physics, and in 1892 he left the Royal College to become a free lance lecturer and writer. Lockyer, however, had realised the quality and promise of his literary work and in 1893 made him assistant editor of *Nature*, which first brought him into touch with Macmillans, its publishers. And so the opportunity came to Gregory to devote his life to securing recognition for science and scientists, and to ensuring that they were given the chance to make the contribution to progress on which he believed the future depended. He had come up the hard way and he did his best to awaken realisation of the readjustments in social and economic conditions that the new technological age was making imperative. Gregory used every means of reaching his objective : education, journalism, the British Association and the British Science Guild.

Education

Gregory had had to fight so hard for his own education and had suffered so much from the lack of textbooks that he saw here a great opportunity. His first book, *Elementary Physics and Astronomical Geography*, was published in 1891. It was the first of many textbooks that flowed from his ready pen or were inspired by his editorship. His own books were notable for their clear writing, systematic arrangement, for their recognition of the relation of theory and practical work, and for the lively interest they created in the practical applications of science. His second book was an elementary physiography, a description of the laws and wonders of nature. After that came *Honours Physiography* with H. G. Wells in 1893 and in the same year *The Vault of Heaven* and next year *The Planet Earth*. Meanwhile, he was getting experience as an Oxford University Extension Lecturer in astronomy and electricity and in 1898 he became Professor of Astronomy at Queen's College. The same year saw the beginning of his long partnership with A. T. Simmons, with whom he started the *School Year* and the series of joint textbooks, which they produced in new editions until Simmons' death in 1921.

In 1905 Gregory became scientific editor to Macmillans, a position he held until 1939. Under his editorship and inspiration some 200 textbooks were published, some with him as co-author.

In the years when science was becoming an increasingly important subject in the schools, this comprehensive series of textbooks covering elementary and advanced courses was a contribution of great value. Gregory devoted himself to this work and many authors, young and old, were grateful for his encouragement and his wise advice and criticism. Editorship for him meant a working partnership with the author at every stage of the book.

But his interest in education did not end with writing and editing books. He was keenly interested in the technique of teaching, in the many problems to be

found in the introduction of what was often a new subject and in securing the proper place for science in the curriculum. It was these wide interests that led him to take such an active part in the formation of Section L of the Association dealing with Educational Science, in 1901. He was its first Secretary and then its Recorder and one of its most active members from the start. The turn of the century had seen a big extension of school science and many experiments were being tried.

Gregory in his Presidential Address to Section L, when it came of age in 1922, gave a sketch of its aims and progress. It had been formed to devote attention to education in all its branches with the object of introducing scientific conceptions into every sphere of educational activity. Gregory defined the business of education as the promotion of the right adjustment of a growing human being to its environment. The scope and character of the subjects of instruction should be determined by this biological principle and must be adjusted to new conditions in the world. 'Science has become a kingdom potent with possibilities for good or evil—an inheritance which cannot be renounced—and to let any children grow up unfamiliar with their entailed possession is to neglect an obvious duty.' . . . 'Science permeates the atmosphere in which we live, and those who cannot breathe it are not in biological adjustment with their environment—are not adapted to survive in the modern struggle for existence.'

Gregory knew the kind of science teaching he wanted to see in schools, its purpose was not 'to prepare for vocations but to equip pupils for life as it is and as it soon may be.'

He was Chairman of a British Association Committee in 1917 which was appointed to report on the essential place of science in school education. It included among its members several outstanding teachers like Sanderson of Oundle and Archer Vassall, and their Report with its suggestions for science courses was the foundation of the movement towards general science. Gregory insisted that general science should be more than an amorphous collection of topics from physics and chemistry with a little natural history thrown in as a sop to the biologists. 'It should provide for good reading as well as for educational observation and experiment; should be humanistic as well as scientific. The subject which above all others has the double aspect is geography. . . . Rightly conceived, geography can be made the earliest means of education as both Comenius and Locke regarded it, and it can be used as the unifying principle of all the generalised scientific instruction in schools.' To-day with our greater knowledge of the world's resources and demands, of the needs of backward countries, of the principles of nutrition and disease, Gregory's forecast is seen in a new light.

He was very critical of examination syllabuses of the type of university entrance examinations which meant sacrificing the needs of the many to the interests of the few. While recognising the value of laboratory work as a training in method, he was insistent on its being accompanied by broad courses which would excite wonder and stimulate the imagination, while providing a knowledge of every day phenomena and the applications of science. His address was a plea 'for the expansion of scientific instruction in this humanising spirit, and for widening the gateway into the land of promise where the destinies of the human race are shaped.' . . . 'I want science not only to be a means of stimulating real and careful thinking through doing things, but also a means of creating interest and enlarging the working vocabulary of the pupils and thus truly increasing their range of intelligence. So may scientific instruction be made a power and an inspiration by giving in the words of the Book of Wisdom (vii. 16–20):

> An unerring knowledge of the things that are,
> To know the constitution of the world and the operation of the elements;
> The beginning and end and middle of time,
> The alternations of the solstices and the changes of seasons;
> The circuits of years and the position of stars;
> The nature of living creatures and the raging of wild beasts,
> The violences of winds and the thoughts of men,
> The diversities of plants and the virtues of roots.

The late Poet Laureate shared Gregory's views. He spoke at the great meeting that was held in May 1916 to draw attention to ' The Neglect of Science ' which was prejudicing in many ways our war effort. It is probably hardly even a memory to most of you, but the recollection of it is a reminder of the progress we have made since then, thanks in no small degree to Gregory's persistent advocacy. Robert Bridges in his final sentence crystallised the inward significance of this new view of scientific learning in the schools. ' It is,' he said, ' the living grammar of the universe, without which no man can ever hope to read in its full significance the epic of his spiritual experience.'

For his Presidential Address to the Science Masters' Association in 1928, Gregory chose as his subject ' Contacts of Science and Literature.' ' As my main functions in life,' he said, ' seem to be those of a scribe and guide, it is perhaps appropriate that in this address I should deal with language and literature in relation to science rather than with scientific education or progress.' Gregory was an omnivorous reader all his life and he had a good literary memory. He begins by comparing the outlook of the scientist and the poet, the one desiring to see things as they are, the other to display the emotional feelings aroused by them. But as Gregory shows by quotations from Tennyson and Shelley their intentions are not necessarily opposed. Scientific truth may often be turned to poetic purpose. He quotes the verse from ' The Cloud ' :

> I am the daughter of earth and water,
> And the nursling of the sky ;
> I pass through the pores of the oceans and shores ;
> I change, but I cannot die.

Those lines had often been seen set for comment in elementary science examinations, and Gregory wonders whether students of English could interpret them so successfully. And that leads him to question whether the indifference to science among the teachers of English is not more general than the neglect of literature by students of science. Gregory was always pressing for a balanced education and he resented the intransigent attitude of scholars and writers educated in classical schools towards the claims of science to an essential place among the new humanities. He rejects on the evidence of the psychologists the concept that the exercise of the mind on one kind of material improves the faculty to deal with all kinds of material, part of the basis of the claim that training in the classics is of unique value. But Gregory was a Hellenist with a deep appreciation of ' the passionate regard for truth, disinterested research, imagination, acute reason and creative intelligence, which were the essence of the Greek spirit.' He admits that ' to certain minds a grammatical generalisation is more readily understood than a principle derived from laboratory measurements, and on that account some pupils who have been trained to apply scientific method to language may be better prepared to take up the study of science seriously than those in whose minds are nothing but loose ends.' What judgment could be fairer ? And he ends with an appeal to teachers of English, classics and history to understand and interpret the human contacts of science with their own subjects, resulting in ' a unity of interest which will give power and a new meaning to all cultural effort.'

His book *Discovery* was one of Gregory's many services to education. Published in 1906, it ran through many editions until in 1949 Gregory revised and shortened it for the Penguin Press, so that the younger generation will not read it in its original form. This I regret as it had a quality of its own in giving a picture of the working of the minds of the great discoverers. Instead of following the historical sequence, Gregory's chapters deal with the different aspects of discovery :—outlook and endeavour, the scientific mind, belief and evidence, law and principle, scientific motive and practical purpose. The book is a revelation of his wide reading, of his first-hand knowledge of the classics of science and of his amazing literary memory. It is interspersed with long quotations from the classic authors which are so aptly chosen that they fall imperceptibly into line with his own lucid lively sentences, while revealing the thoughts of many of the greatest scientists of the past and the literary quality in which

they found expression. The quotations at the head of each chapter show, too, Gregory's range and discernment. The book has such freshness and vitality; it arouses human interest on every page; it is written with such zest and enthusiasm that it should be reprinted in its original form.

Sir Edward Salisbury, a few weeks ago, when he was opening the new biological laboratory of the University of the South-west, spoke of the present-day dangers of specialisation of the young scientist confined within the ever-growing complexity of his own field. Gregory's appeal was for some knowledge of the purpose and accomplishment of science by the young layman. His book *Discovery* seems to me so admirably suited to meet this dual need as an introduction which will arouse interest and stimulate wider reading. Gregory carried in his mind the whole story of discovery through the ages, he knew the personalities of the great men and their writings, and so with the touch of the journalist at his best, carrying his learning lightly, he has given us this vivid picture of the different aspects of the advance of knowledge. Astronomy, geology, biology, chemistry and physics are all woven together, as he drew his examples from the old masters and the new.

Journalism

Almost from the day that Gregory became Lockyer's assistant in 1889, he was writing popular articles on astronomy and Lockyer was quick to see the qualities —his lucid style, his gift of phrase, his sense of the significant—that were to make Gregory the greatest scientific journalist and editor of his time. Love of science and an imaginative sense of the part it was destined to play in human affairs were the mainsprings of Gregory's life. But in addition he had the shrewdness and the practical judgment, sharpened by his early struggles and adversity, which helped so much in the success of his editorship of *Nature*. Of all his Presidential Addresses, and he must easily hold the record both for their number and the variety of their subjects, his Address on 'Science and the Press' to A.S.L.I.B. at Oxford in 1934 is in some ways the most significant as it contains a searching analysis of the parts an editor and manager must play in the life of a newspaper. It reveals how his keen mind had appreciated the factors that make for success or failure. And it is interesting to compare it with the terse, crisp sentences in which C. P. Scott wrote 'On Journalism' in the centenary number of the *Manchester Guardian*. The two men thought alike. 'In all living things,' wrote Scott, 'there must be a certain unity, a principle of vitality and growth. It is so with a newspaper, and the more complete and clear this unity, the more vigorous and fruitful the growth. . . . A newspaper has two sides to it. It is a business, like any other, and has to pay in order to live. But it is much more than a business; it is an institution; it reflects and influences the life of a whole community; it may affect even wider destinies. It is, in its way, an instrument of government. It plays on the minds and consciences of men.' *Nature* under Gregory certainly became an institution, both in the international and in the national field, for he made it a clearing house for new ideas. A letter to *Nature* became the accepted channel of rapid communication to the scientific world of a preliminary note of some new technique or discovery. But that was only one of its functions.

Lockyer made Gregory his assistant editor twenty-nine years after he had founded *Nature*. As years went by more and more of the work fell to Gregory and he was virtually editor a long time before Lockyer resigned the office to him in 1919. Gregory had his own ideas and new features were introduced like the leading articles the first of which appeared in October 1915 on 'Science in National Affairs.' From November 1919 when he took over they appeared every week, many from his own pen, dealing with scientific developments which had national importance. Some of their titles in 1919–20 indicate Gregory's wise discrimination and foresight in the subjects he chose: The Nurture of Key Industries, The Need for Aircraft Research, The Organisation of Scientific Work in India, Meteorology and the State, Science and the New Army, The Cost of Scientific Publications, the Present State of the Dye

Industry, Naval Education, Aerial Navigation and Meteorology.

The years of Gregory's editorship saw an immense increase in the number of scientific workers and a rapid growth of specialisation with the increasing complexity of problems in each field. Entirely new fields of investigation were opened with new techniques and there was a great extension of industrial research. All this combined to make it more difficult to watch developments all over the world. But under Gregory's skilful guidance *Nature* made this possible.

The late Lord Rayleigh in thanking him for his Hinchley Lecture to the Institution of Chemical Engineers on Scientific Knowledge and Action spoke of the great debt that all scientific men owed to Gregory for more than a generation. 'Looking back on his own scientific life,' he said, 'he found it difficult to imagine how he could have carried on if he had not had the constant privilege of reading the pages of *Nature*, a journal which kept one in touch with science in all its branches.' I remember very well as a schoolboy being introduced to *Nature* by H. B. Baker—"dry reaction Baker"—and I read it eagerly each week. When I returned from a scholarship examination at Oxford, Baker greeted me by saying, "Well your reading of *Nature* must have paid a good dividend," and from my point of view it certainly had.

Lord Rayleigh spoke of the nice discrimination with which *Nature* avoided any reference to discoveries like the death ray which were trumpeted in the daily press, and his own reliance on the authority of *Nature*. He wondered how Gregory managed to keep in touch with all branches of science in all countries, 'but somehow or other the thing was done and scientists as a whole were glad to benefit by the result, even if they were mystified by the process.'

In his early years Gregory stood almost alone as a scientific journalist and in his A.S.L.I.B. Address he lamented the scant encouragement given to science writers since so few newspapers or periodicals had on their staff someone capable of dealing intelligently with scientific subjects, of equal standing with their special critics of art and music, or of racing, golf and tennis. As a result the public lacked in science the enlightened guidance they received in other matters. 'Most people have yet to learn,' he said, 'how and why science and scientific thought are the determining factors in the chief problems of progressive life.'

Gregory admitted that one difficulty was that many investigators were too busy and were often ill-fitted to be popular interpreters, which made it all the more important that there should be a class of science writers with some organisation behind them, like Science Service, the non-profit making corporation in the United States, founded in 1921 by a newspaper editor and proprietor, the late Mr. E. W. Scripps. He ended with an appeal to the press and to the man of science to get together and find a remedy.

That Address was given nearly twenty years ago, and Gregory's advice has not gone unheeded. Particularly in the B.B.C. much has been done to make the public realise the outlook of the scientist and the impact of his work in almost every field of social and political well-being. It needed the experience of a Second World War to drive home the lessons of the First, but that demonstration of the power of science left in the minds of many a deep mistrust. Gregory himself repudiated the use of the atom bomb as repugnant to the ethics of the civilised world.

British Association and British Science Guild

Of the many attachments Gregory formed during his life the longest and the most intimate was his membership of the British Association, and it was there that he was best known to the younger generation. He joined as a Life Member in 1896 and his attendance came near to being proverbial. In his telegram last year to us at Belfast he spoke of unbroken attendance at fifty-two meetings. From the first he threw himself into the work of the Association with immense energy and devotion, not only in Section L, but on endless committees and as a member of Council for many years. He was always ready with constructive suggestions and he was one of the stalwarts who gave continuity

to our meetings. The B.A. owed much to Gregory but the debt was amply repaid when at the meeting in South Africa in 1929 he met in Johannesburg his future wife. She, too, has won our affection by her devoted care of her husband who relied more and more upon her as years went by. Let me quote Gregory's own tribute to her, ' My dear wife Dorothy has brought into my life more happiness than anyone else and whatsoever I may possess when I am called away cannot be more than a poor return for her sweet love and tender care.'

But much as Gregory believed in the British Association he followed Lockyer in thinking that its activities should be extended to influence public opinion and promote closer contact between science and public affairs.

In his Presidential Address at Southport in 1903 on ' The Influence of Brain-Power on History ' in which he paraphrased the title of Captain Mahan's famous book which did so much to arouse public interest in the Royal Navy, Lockyer urged the need for an organisation to enable science to speak with a collective voice, so that it might counter the neglect which had become so dangerous, when Britain's industrial and military strength were both threatened with severe competition from abroad, competition based on education and scientific research. Lockyer gave striking figures to show how science was being starved in Britain as compared with the large sums being spent in Germany and the United States on the endowment of Universities and research. He quoted Huxley's dictum that we were in the presence of a new ' struggle for existence,' a struggle in which science and brains take the place of swords and sinews, the result of which would be decided in the school, the University, the laboratory and the workshop.

It is perhaps difficult for the present generation to realise how backward we were. The total annual Government grant to Universities and University Colleges in 1905 was £155,000, while the University of Berlin ten years earlier was receiving £167,000. Lockyer pleaded for a duplicate of the Navy Bill of 1888 when twenty-one and a half million were voted for a five-year building programme.

Quoting the last words of the original objects of the British Association—' to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which might impede its progress '—Lockyer argued that here was a great opportunity to expand its functions. ' This magnificent, strong and complicated organisation would become a living force, working throughout the year instead of practically lying idle, useless and rusting for fifty-one weeks out of the fifty-two so far as its close association with its members is concerned.'

However, the Council did not see its way to set up such a wide organisation as Lockyer had outlined, possibly doubting the wisdom of becoming involved in national and political affairs. And so the British Science Guild was formed in 1905 with Lord Haldane as its first President with the objects of creating a general awareness of our future dependence on scientific method and research, of pressing for greater support for Universities and research institutions, and of bringing to the notice of Parliament the scientific aspects of matters affecting the national welfare.

Gregory was at first a little doubtful about this breakaway from the Association, but he soon saw the advantages of the Guild as an agency for propaganda backed by men in public life like Lord Haldane, Lord Sydenham, Lord Montagu of Beaulieu and Lord Melchett. By public meetings, by reports of Committees, by lectures and by close contact with members of Parliament, it was able to stimulate public interest continuously during the critical years of scientific development. Over twenty urgent national problems concerned with scientific effort were investigated by strong Committees, and in this way the Guild made a major contribution towards a number of improvements, among them : the Treasury Grant for developing a National Physical Laboratory ; the creation of the Development Commission for Agriculture ; the establishment of a Department of Scientific and Industrial Research ; the Patent Act of 1932, and the formation of the Parliamentary Scientific Committee.

In all of this Gregory soon became the

moving spirit and from 1922 he was Chairman of the Executive Committee. He drafted many of the Reports and the work of the Guild had strong support in *Nature*. He organised the exhibitions of British Scientific Products in 1918 and 1919 for which he received the recognition of a knighthood.

There is no doubt that the Guild did most valuable work and the Norman Lockyer and Alexander Pedler Lectures founded in 1925 and 1929 were a constant reminder of the importance of science in human progress. In 1923 when the first suggestion was made to unite the Guild and the Association, Gregory was opposed to it, as in his view the two bodies were essentially different. ' The B.A. consists of priests and noviciates of science, while the B.S.G. represents a missionary effort to proclaim a new gospel.' Negotiations were renewed from time to time and finally in 1936 proposals for amalgamation were approved by the British Association at the Blackpool Meeting. In 1938 the Division for Social and International Relations of Science was formed with a Committee embodying the existing B.S.G. Committee, with powers to hold meetings not necessarily confined to the Annual Meetings of the Association, and a new journal, *The Advancement of Science*, was substituted for the old Annual Report.

It is true that the Division under Gregory's Presidency kept the Association active during the war. But looking back at what the Guild accomplished and looking forward to the problems this country has to face, I question whether the fusion was in the best interests of science. Has not Gregory's original objection been fully justified by the results ? The Guild could enlist the sympathy and leadership in the cause of science of men in public life. It provided a forum where a group of men of affairs could discuss with men of science. Under Lockyer's and later Gregory's watchful eye it could and did address itself immediately to national problems when science was concerned. Its success in later years was due largely to the energy and vision of Gregory and his friends. It was not only a missionary but an invaluable watchdog. Has its offspring, the Parliamentary and Scientific Committee, effectively taken its place ?

The Visit to America

In December 1938, just as he was leaving the editorial chair, Gregory was invited to give a series of lectures in the United States at the Carnegie Institution, in Columbia, Harvard and Johns Hopkins, and to address our sister body, the American Association for the Advancement of Science.

The tour was a great success for Gregory was at his peak in his seventy-fifth year as an eloquent exponent of the gospel of science, and he felt the thrill of the occasion. He had seen clouds gathering on the horizon and his addresses were a declaration of his faith in what science could contribute to a disordered world if it were not perverted to destructive uses in the lust for power. Gregory feared the growing tide of nationalism as a disintegrating force in a world which science could help to unify. In 1938 he recalled Soddy's Cassandra-like prophecy of the atomic bomb.

The Greeks had dreams of the Golden Ages of the Past, they had no word for progress, but Gregory had visions of the Golden Ages of the future, if man would use his new understanding of Nature to good purpose.

His Elihu Root Lecture to the Carnegie Institution of Washington, on Cultural Contacts of Science was the most finished and carefully argued of all his addresses, and it gave the best picture of the run of his mind and interests. It deserves to be reprinted as it is unknown in his own country. In it he counters the view that scientists are materialistic, insensitive to beauty and incapable of deep emotion, that the scientists idea of the evolution of mankind is the law of the jungle, ' Nature red in tooth and claw.' Through all his American addresses there runs the motive of his favourite quotation from Huxley, his Dean at South Kensington, in *Evolution and Ethics* : ' In place of ruthless self assertion it demands self-restraint in place of thrusting aside, or treading down or competition, it requires that the individual shall not merely respect but shall help his fellows ; its influence is directed not so much to the survival of the fittest, as to the fitting of as many as possible to survive.'

The future of the world depends,

said Gregory, on the use of science in the spirit of the Sermon on the Mount.

One of the themes of the Elihu Root Lecture was the relation of science and literature. He quotes fine passages from Kepler and Newton, examples of de Quincy's ' literature of power ' as contrasted with ' literature of knowledge ' which ' survive because of their human feeling naturally expressed.' He quotes the famous passage in Wordsworth's introduction to Lyrical Ballads : ' Poetry is the wealth and fine spirit of all knowledge . . . it is the impassioned expression which is in the countenance of all science.' 'Poetry,' says Gregory, ' and other forms of literary and artistic expression once followed more closely on knowledge than they do to-day. . . . Poetry, philosophy and science all began life together as children of one family. . . . The greatest singers of antiquity were the most alive to science.' And then he turns to the history of the earliest science, astronomy. ' The science most closely associated with spiritual feeling,' and traces its relationship through the ages to religion, and other reflections of current thought in literature and philosophy. He follows the gradual emergence of the conception of law and order to nature and of divine purpose through the study of celestial bodies in Babylon, in Egypt and in Greece. Then from his knowledge and love of literature he illustrates the inspiration that came from man's contemplation of the skies in the Bible and in the poems of Virgil and Lucretius, of Dante, Chaucer and Milton.

Through all this Gregory is tracing the pursuit of truth and its high moral and spiritual influence in whatever field it is the motive of action. Science is not to be regarded, ' merely as a storehouse of facts to be used for material purposes, but as one of the great human endeavours to be ranked with arts and religion as the guide and expression of man's fearless quest for truth.'

When he returned from America Gregory collected all the materials for his lectures and embodied them in a book *Religion in Science and Civilisation.* This was published in 1940, but alas, nearly all the copies were destroyed in an air-raid, and then with his energy unabated at the age of eighty, he set to work and recast it under the title of *God and Men* which was published in 1949.

Among the many appreciative letters he received about the book, those from Dr. George Trevelyan and Mr. Mackenzie King gave him special pleasure. Dr. Trevelyan said he was astonished that one who had given his life to science should have been able to take so wide and deep an interest in history. ' I see you are a great age now which makes my wonder of the book all the more.' Mr. Mackenzie King, writing just after his resignation of the Premiership of Canada, said that the book had given him what he most needed —' A place of new beginning ; something to restore a true perspective.'

President of the British Association

In 1939 came the war and Gregory had been elected President at Dundee the day before war broke out. The Annual Meetings of the Association had to be abandoned but the formation of the Division for the Social and International Relations of Science gave the opportunity under Gregory's leadership for a series of conferences to discuss questions that would be in urgent need of solution when the war ended. The ideas of the founders of the Science Guild were thus given scope for expression and action. There were eight Conferences in all over which Gregory presided and at the first on Science and World Order he enunciated a ' Declaration of Scientific Principles ' which was in effect a ' Hippocratic Oath ' for scientists.

These Conferences kept the Association in action during the war and they certainly achieved their object of providing opportunities for the discussion of post-war problems. Their subjects covered a wide field and perhaps the most successful were those on Mineral Resources, The Place of Science in Industry, and Science and the Citizen, at which Gregory read a paper on Science and the Press in which he emphasised the need for continued education on the impact of science on social relations.

Gregory's was the record Presidency of seven years from 1940 to 1946 when he

delivered his Presidential Address at the first short post-war meeting in July. His subject was Civilisation and the Pursuit of Knowledge. In it he recurs to his favourite topic of his later years, the gradual emergence of civilisation through the ages and the history of early religion with its close association with the heavens. Then he outlines the development of the schools of philosophy and the growth of natural knowledge, science and invention. Gregory's anxiety was the use that man might make of his new powers and he ends with a moving appeal for goodwill and goodness of heart in the choice between the good and evil fruits of knowledge.

His last speech to the Association was at Birmingham when he moved the vote of thanks to Bishop Barnes for his Sunday Evening Discourse on ' Science, Religion and Moral Judgments.' The Bishop's subject was close to Gregory's heart and he was at his happiest in his appreciation of the address, with all his old zest and enthusiasm and his readiness to find *le mot juste*. We saw him for a brief space at Edinburgh where he was taken ill ; for a year he was an invalid and then in September 1952 his active spirit quietly flickered out.

Epilogue

I began with the idea of making this lecture mainly a study of the times of Richard Gregory but I quickly found those times becoming just a background to the human interest of his life of endeavour and success—a success which is so encouraging a story in the days when there were few of the educational escalators of the present time. I have told the story as far as possible in his own words which were so well chosen.

Gregory's long life of nearly ninety years saw the most rapid and eventful changes in the outlook and fortunes of mankind. First came the battle between the evolutionists and creationists and the emergence of the liberal interpretation of the Holy Scriptures that we know to-day. Next came the gradual recognition of our social responsibility for the human adjustments that were needed in an industrial civilisation, which have changed so profoundly the social structure of this country. And alongside them came that pride of discoveries, the electron, the nucleus, the quantum and relativity, that have given a fresh insight into the nature of matter, of life and of the universe. And with that deeper insight has come a new humility in response to the ever receding vistas of the complexity of the unknown.

With the advance of knowledge came a new power of man over his environment, the possibility of a new partnership with Nature in place of the struggles of primitive man. Evolution has moved fast, quickened by the needs of two World Wars, that have left such deep scars behind them.

Of all this Gregory, so far as science was concerned, was the interpreter, or as he called himself once ' the standard bearer ' and he had ideal qualities for the task. He was no specialist, nor in that sense a profound thinker, he did not engage in the details of polemics. He saw the broad picture and its human bearings for he was essentially a humanist. He had the gift of leadership, persuasive, resourceful and quick in action. He had a ready humour and a fund of stories. But above all he was one of the most generous of men, generous in his help and gifts, generous in his praise, and sometimes too generous of other people's motives.

Success and recognition came to him in many ways and he enjoyed them to the full. It was his generosity towards others that made his successes such a pleasure for his friends. The honours that pleased him most were his knighthood and his baronetcy, his election to the Royal Society under Statute 12 in recognition of his conspicuous service to the cause of science, his election to the Athenaeum under Rule II, the presentation to Lady Gregory and himself from the British Science Guild, and finally his Presidency of the British Association.

Gregory was an optimist and saw the best in everything and everybody. This made him sympathetic to new movements which seldom came to him in vain for help. And perhaps, too, it was partly the inveterate old journalist in him peeping out, eager for news. From first to last he was a member of over seventy societies

and institutions and a moving spirit in so many.

But it is as the editor of *Nature* that he will be best remembered in the future, for his wise, shrewd, imaginative guidance that gave *Nature* its unique position in the scientific literature of the world. The driving force behind all he did was his devotion to the interests of science and his belief in its message for the future. Gregory wrote his own epitaph :—

> My grandfather preached the Gospel of Christ ;
> My father preached the Gospel of Socialism ;
> And I preach the Gospel of Science,
> But the ethical principles of all three are pursuit of truth and righteousness for the improvement of man and society.

To Sir Edward Appleton

on hearing his Presidential Address to the British Association, 1953

Within the hush'd and crowded hall, now gay
With learning's silken panoplied array,
We sit enrapt ; companion'd, warm, secure
In a familiar world, serene, demure ;
Our minds elsewhere, above the veil of night
Borne on imagination's thrusting flight
Through the unending, roofless vaults of space
Where galaxies pursue their timeless race
In distant majesty ; about them spread
A seeming frozen silence, deathless, dead.
Did we possess your magic, we might hear
The voiceless ether murm'ring low and clear
A myriad soft whispers, mystic tone
Of outer worlds, the known and yet unknown.
How wise the mind that thus can apprehend
A universe too vast to have an end,
The ear its ghostly note detect, the hand
A new strange music of the spheres command.

Stanley Dumbell.

GATEWAYS OF SCIENCE

Address by

DR. W. E. SWINTON

PRESIDENT OF THE ASSEMBLY OF CORRESPONDING SOCIETIES

THIS Liverpool Meeting is the 115th of the British Association. It is the latest of a great series that represents a notable chapter, indeed a volume, in the history of science. It is part of science itself; and the collation and assessment of science done by the Association in that time has been of immeasurable value to people all over the world.

The history of this Assembly, formerly the Conference of Delegates of Corresponding Societies is neither so long nor so brilliant. Whereas the whole Association has listened to the experts and the oracles, we in our humbler ways, have been content to discuss, as mere general practitioners, the problems of a more workaday world. That is not to say that we have not had our distinguished presidents or to deny that more than once the path of duty here has led to glory in the larger sphere. It is certainly true that it makes the choice of a subject for a presidential address no easier and I have looked with some dismay at the range and excellence of the products of my predecessors.

Fortunately, as the physicists now tell us, the part is not merely part of a whole, but that whole can, in some measure, be interpreted as part of the part. In every space-time relationship there is mutual need of the parts and there may even be reversal of their roles. Though I should hesitate to say outside of this room that the Assembly is more important than the Association of which it is a necessary part, I do propose to devote myself to the rather different functions which we now serve and the different environment and climate of opinion in which they are set.

This indeed has been a year of memories and of historical associations. If we look back towards the formation of the Conference in 1885 we see a time of political unrest at home and abroad, but science was rising, and, while we were meeting in Aberdeen, London was having its first considerable exhibition by inventors. For the general mass of the people it was a time for wonder. Science was rising like a star, and like a star it could be admired, though only from afar. Like a star it was far off and the candles of men were not yet put out by its light. Men were beginning to realise the power, and more especially the potential wealth of science, perhaps in the reverse order. Thanks to the wise provisions of the Commissioners of the 1851 Exhibition, some people were being led to investigate the careers that science might offer, but, in general, even at that not too far off date, it brushed the life of the ordinary citizen little more than did star dust.

The years between have seen the spread of science into education, into the state, into men's lives, and even into the business of the politicians. It is no longer the wonder or the idol, it has become the companion, the daily help, the workmate, as well as the oracle. It is now generally agreed that it holds and is the key to the future.

This rise of science has very properly been accompanied by a steadily increasing public interest, in both its fundamentals and its fringes. In this the Association has played a major part. It has actively contributed to the advancement of science by bringing together men of ability practised in wide ranges of appropriate subjects, by its committees and research grants, and above all, because in its annual meetings it has shown the fundamental importance of science in daily life and the necessity for early recognition that its trends can, and must be, guided.

The Presidential Address at Belfast last year by Professor A. V. Hill, gave a direct challenge to those who believe it is only necessary to start or to accelerate scientific works and reminded us that constant individual thought and public guidance are necessary for the direction and redirection of policy ; indeed the need has become a public charge.

This sense of public responsibility and of continued interest are largely seen in the Association, which has become the annual general meeting of Science at which the directors make some sort of report to the shareholders. The interest of the press and the space devoted to the proceedings are proof of a general interest that extends far beyond the place of meeting or even the country. Locally the last two meetings have shown a remarkably large number of residents who have given personal and financial support to the meetings. The new series of lectures for younger persons and the welcome encouragement given by local and regional educational authorities are the beginning of a new chapter, perhaps again even a new volume, in both the history of the Association and of education.

It is clear that these new circumstances demand a reconsideration of the work of the sections, such as this Assembly, so that it, like them, can play an appropriate part in the reorientation of the opportunities and responsibilities and also that it may lay the foundations of a more lasting interest in certain aspects of science than can perhaps be engendered in the brief period of the annual meeting.

None the less, it seems clear that however wide the appeal of the Presidential Address may be, the programmes of the sections tend to become more and more specialised ; the sections themselves more and more a place for the younger generation to demonstrate its ability, which is admirable, but perhaps on the whole to simulate a travelling scientific society, anxious to show as widely and as deeply as it can the rich technicalities of its progress. This is not by any means to decry the work of the sections. It can be argued that the members of the public are becoming increasingly educated in general science, and that in any case, none loves jargon more than the new initiate. You will remember T. H. Huxley's story of Faraday, one of the greatest lecturers of all time, who was approached by a young man anxious to know the tricks of the trade. ' How much can I assume my audience to know when I give a public lecture ? ' he asked. And Faraday replied ' Nothing.'

In the years that have passed since then it is doubtful if the quality of lecturing has risen ; but surely the standard of education in the general audience has. And unless it has done so considerably, many laymen will not derive much from many of the items on the sectional programmes. Yet, in each science, the rise of new discovery is so rapid, the increase of workers so promising, and the inter-relations of each so involved, that the brief week of meeting is far from long enough for the workers in one group to hear the recent advances of their fellows.

From all this, even if it is accepted as only partly true, it seems clear that the fundamental idea of the Association as a body for explaining the trends of science is now generally so only in the President's Address and in a very few items elsewhere. It follows, therefore, that there is an immense opportunity, indeed a duty, laid upon this Assembly to take up the function of accountant for science ; to render unto the public the things that are theirs so far as information is concerned ; and to provide at least an annual forum for questions and even answers.

This is not a departure from the conditions laid down in our statutes and regulations. The specific obligation on the Conference of Delegates was ' the consideration of matters of common interest to the Association and the (Corresponding) Societies and to make recommendations to the Council ' ; and that ' The Conference may also discuss propositions regarding the promotion of more systematic observation and plans of operation, and of greater uniformity in the method of publishing results.'

These functions have now officially been taken over by this Assembly, now one year old. It has the advantage that its meetings are no longer confined to delegates but are open to any who care to attend ; and that the occasions for meetings of the members are much extended,

and, indeed, can be as numerous as its Recorder cares to arrange within the statutory time.

All this therefore confers upon me the duty of examining with you the question as to how far this body can direct inquirers for scientific information not only during the local opportunities of the meeting but on a more permanent and wider basis.

I have called this address ' Gateways of Science ' for three reasons. Firstly because it seems to me that we are compelled to be interested in what comes out of science, that is, information ; secondly, because we must also be interested in helping people, young or old, to get into science for work or pleasure or both ; and thirdly I have used the word Gateway rather than Pathway because it implies the existence of a gate, an obstruction that causes at least some exertion on the part of him who wishes to enter. Despite all the grants of all the societies and committees there is still some effort required in these pursuits.

Now, the exit of information, the entrance of students, can be accomplished in various ways but they all follow much the same route. We have long been interested here in the scientific societies, and no fewer than 166 are affiliated to us at this moment. Each of these can be represented at this meeting by up to six delegates, provided each delegate joins the Association for the meeting. We could thus be quite a formidable body and many of these societies are fact-finding, research-directing bodies of primary importance in at least one field of science. Others are combinations of societies, such as the Unions, representing in one way or another, an extensive range of field clubs, microscopical, geological, botanical, entomological, and archaeological societies. All in all, with their accredited representatives and those others who might feel attracted to it, we could have in the Assembly a very large and influential company. There would be much for us to discuss in any case ; the maintenance of the societies, why memberships are dwindling, why young people do not come into the societies at the rate they might be expected to do, and much about the difficulties of publication. At least these are the sort of things one hears frequently at meetings of the individual societies.

After such an analysis, there remains the important task of making such observations as inevitably emerge ; to repair what I think are serious omissions in a wide but cognate field ; to examine our place with respect to current trends in the education of both young and adult ; and to outline a scheme whereby the Assembly can create a new plexus that may, I hope, become an integral and even vital part of the Association as a whole.

It is in this field, especially of adult education, that we must now attempt to play a leading role. The forerunner of the Assembly, as already stated, was the Conference of Delegates of Corresponding Societies. What were these societies founded for ? If we look at the time of their foundation we see a world much different from that of to-day. The working hours were long and the time for leisure almost non-existent. Yet it was in these circumstances that the literary and philosophical societies, the mechanics' institutes, and the majority of our museums were being founded. The fact that many of these have managed to continue functioning until to-day gives some idea of the vigour that launched them. But, it can be argued, the alternative means of entertainment and instruction were then almost negligible. If leisure was scarce there was not much competition for the use of that leisure and if the number of younger persons in the societies was greater it was for a fairly obvious reason. Another, less obvious, reason was that as the school-leaving age was ridiculously low, these younger devotees of the sciences were, in fact, part of the adult education of the time. One has to remember that the Workers' Educational Association, great as has been its work, was not founded until 1903.

The position to-day is much different. School leaving age is 15 ; leisure throughout the country and in all classes of the population is very much increased ; and if the diversions are immeasurably greater they are certainly not all educational. Books, however, are far more numerous, wider in range of interest, and relatively cheap.

School education is itself very much

wider in scope; the so-called visual aids cover a wide field, and the excellent broadcasts to schools, and many other activities compressed within the crowded halls of the schools, may give a less deep basis of general education than once was the case. I say may give, for I myself am not qualified to judge, but quite recently Sir Maurice Bowra, lecturing to the Institute of Education in Oxford, said that 'schools attempted too much and allowed too little free time; the pupil was rushed from easel to oboe and thence to a civics lesson; nor could he read enough without supervision, and he left school less well read than previous generations' (*The Times Educational Supplement*, March 20, 1953, p. 249).

Last year, at the Belfast Meeting, Mr. Brimble, editor of *Nature*, pleaded anew for the three R's, and wisely said that it was not much use being clever or even a good scientist if one could not write or speak sufficiently well to let the rest of the school or the country or the world know and benefit.

Mr. Harold Clay, president of the W.E.A., told the Harrogate conference of that body earlier this year that he did not believe that secondary education for all, or the system of selection at eleven plus, had eliminated the need for the Workers' Educational Association. He added 'While schooling for the majority stops at 15, the W.E.A. is needed as much as ever it was.'

Recent experience of school attendances in the British Association, with only last year and this so far to guide us, is far too short for making any judgment, except that one realises the enthusiasm of scholar and teacher for the ripe fruits of experience and the eloquence of the chosen lecturer that are available here.

Is an interest in science really inculcated by such things? Or is it merely a temporary infatuation with what appears to be the scientific way of life? Or is it the publicity associated with the meetings that tickles the palate of youth?

Herbert Spencer in his book *Education* was emphatic that Natural History was good for children and that it trained the eye. He was also a great believer in the intrinsic value of the teaching of physical science 'whose truths,' he prophesied in 1861, 'would bear on human conduct in 10,000 years as they do now.' Alas for the passage of time, so that one sees the freedom of the fall of apples and the theory based upon the phenomenon alter in much less than that. Does the school study of science, and the examinations based upon it, sicken the pupils, as it is alleged, for example, that the reading of Sir Walter Scott does, until they recover again at a more mature age? Spencer does not deal with the point but history relates that his views on children were not very reliable and that he was not individually successful.

It is certainly a point of interest for us as to whether the school classes really stimulate the interest in science or whether independently the salaries offered for physical scientists act as the spur. I am certainly told often enough, especially by those connected with Educational Authorities, that there is a great scarcity of biology teachers. It is here, I think, that we must endeavour to take some step of practical value. With both the teaching and practice of science there should be abounding experience in the Association and especially in this Assembly. Even if Benjamin Franklin said 'that experience keeps a dear school' I do not think we need be dismayed and I feel that some organisation on a permanent basis could be created so that the voice of the best experience in each field of science, regarding the ways of entry to the profession, might be available, not perhaps to each individual child, but at least to the local authority and the educational committee.

What the calls might be on such a service time alone can tell, but if the best means of fact finding in career research are to be available, I think there is no question as to the source that can provide them best.

The scheme would have other advantages than to the individual. It is a sad fact that on the education committees of most local authorities the voice of experience is only added by co-option, and that in many areas only school teachers seem to be eligible for this. It is not to slight that distinguished profession to say that there are, of course, wider fields of knowledge and of educational practice and that the bringing together of the

representatives of several would do nothing but good. Only in this way can the path into the serious study and practice of the higher levels of science be obtained by many older children.

But whatever happens children leave school and for many of them sooner or later, further education, adult education, becomes necessary. We all know of the attractions of getting away from school but many individuals find themselves eventually in dead-end jobs, the attraction of high initial wages being more than balanced by the small wage rises of the later years and by the intolerable monotony of jobs that can be done by beginners almost as well as by older hands. This can, and often is, offset by demands for higher wages without increase in merit or work but it is also often overcome by the realisation of the more laborious but rewarding methods advocated by the Workers' Educational Association. This body is justly famed for its services and its continued recognition of the need for intellectual leadership and the fact that a 'rich popular culture' is a national desirability.

Yet the demand for the latter has frequently come from the people themselves. For over a hundred years philosophical and literary societies have catered for the growing intellectual needs of those who practise self-help. From such societies have sprung others devoted to natural history and archaeology, providing for those whose energies have demanded a more personal acquaintance with the evidence for science. These people have made simple regional surveys, have amassed collections, some of which are still revered to-day, and have founded museums to serve, at least initially, as repositories for their trophies and as meeting places for their discussions.

In these early and momentous efforts I believe that one sees the effects of the Industrial Revolution; a new spirit of inquiry was abroad and it seems to me that it was no coincidence that the great Exhibition of 1851, the Medical Act of 1858, and the publication of the *Origin of Species* in 1859 all rapidly followed one another in the new atmosphere of education and an interest in science. During the decade around 1859, forty museums were founded in England; seven in Scotland, one in Wales and one in Northern Ireland. An analysis of these is interesting for it reveals that among them were the foundation, or the opening, of the Victoria and Albert Museum, the Science Museum and the Reading Room of the British Museum; museums at Kew Gardens; the University Museum, Oxford, the Fitzwilliam in Cambridge (at least in its present building), and the Museum of Zoology, Cambridge. Local society museums were founded from Berwick-on-Tweed to Lewes, and from Reigate to Penzance. Of the municipal museums there is the immediate regional interest of Liverpool and Warrington, of Stockport and Salford. There was thus an intense movement in all strata of education and of society. I believe that again it is no coincidence that the association of social betterment with educational activities and a desire for knowledge of nature was stronger then than it is to-day when social security is part of every individual's birthright. It is strange for us to think that for nearly ten years after the publication of Darwin's great work executions in England were being carried out in public. It may be assumed that the advance of biological knowledge actually heightened men's dignity rather than lowered it. If in those far-off days they believed in doing most things for themselves, at least the legacy of their efforts remains to stimulate the few who ponder on these things. That is why I mention them here; not because of the attraction of their history but of the facts which have directly led to the presence of most of us here this afternoon and impose upon us the need to re-examine the present conditions and adapt the institutions to the fresh needs.

It is a remarkable thing that despite the antiquity of museums, for example, despite their use to schools, the school loan services they organise and administer, their uses in broadcasts and now in television, they have never taken their proper place, at least in the official view of adult education. In this respect the official use made of their resources and of their staffs has fallen far short of what it ought to be. Fortunately that view has never been the one adopted in the British Association and the local museums and their officials have

often played a part, sometimes a distinguished one, in the meetings.

In this country there are still 500 museums whose collections, whose history, and whose continuing function enable them to play some part in the advancement of science. Behind the museums in many cases lie societies still playing their part in the stimulation of the interest of the younger, if not the young, members of the community. The claim that most of these societies are wholly in the hands of the older members is probably largely true. It probably has always been true. The young are generally engaged in other pursuits for the first decade after leaving school and it is not till later, as a rule and for a variety of reasons, that they rediscover education and culture and the societies that are arranged to provide them. It is only then that they take their place in the ranks of the members of local clubs and societies.

This is admirable enough in itself but there is in fact little organised for such people in a particular way and their search for some forms of education may often take the long way round.

To-day a reasonable estimate of the number of such scientific societies is about 500. A fair proportion of the more vigorous bodies is represented here. Once again the British Association has long recognised their value while other official bodies have left them out of account.

Behind all these there is still another, an enormous, source of public, and especially adult, education. This is the library service. Mr. Henrik Jones, the Public Relations Officer of the Library Association, very kindly gave me some up-to-date information a few weeks ago. There are in Britain 600 library authorities, i.e., county councils, borough councils, urban district councils, and so on, They administer no fewer than 25,000 library points. These latter vary much in size and content, from such places as the magnificent public library of Liverpool to the travelling library van of the rural areas, but they are all places from which scientific inquiries can be initiated and from which books dealing with any aspect of science can be demanded and received. In each case the ultimate resources are the same. The Library Association and many local librarians will provide reading lists and sources of information. Through the Inter-Library Loan Service, which works largely through the National Central Library, almost any work is obtainable by almost anyone almost anywhere. In this way even the libraries of the great scientific societies are to some extent available to members of the public. So far as I am aware this kind of service is unique, and it is also unique that we here in this Assembly have taken so little note of it. In this we have apparently followed the official view, for in the great tribunals that consider adult education one seldom, if ever, sees a museum man, a librarian, or a local society official, at least as such, in the lists of appointed members. As for the public place in libraries, recent research by the Further Education Section of the B.B.C. reveals that there are nearly 13 million registered readers in the country.

It follows, therefore, from this particular survey of our constituents, of their history, present position and companions, that there are three major avenues of adult education, or self education, freely available. The museums, the libraries and the societies. Naturally things have more local potential where the museum and library have attractive and well-managed headquarters, and the society is fortunate and most useful where its treasures are added to continuously and when it has headquarters, storage and accommodation for books, in one of these two institutions. Such permanence of function and address have obvious advantages for co-operation.

Let us think what all this means. If there is only one devotee of science in every appropriate museum, or in every well functioning local society, and only the fantastically low estimate of one in every ten of the many library points, there are no fewer than 3,500 persons whose interests are the same as ours; nearly 4,000 people who ought to be here to-day. They are obviously not in this room but they do exist. Not 99 per cent. of them yet have the advantages of membership of the British Association and if they are to do so then I feel we here must hasten to remedy our omission and to devise some service for them.

Since I feel that we have a duty towards them, I believe, that here and now, we should lay the foundation of a Research Committee which, in the first instance, will co-operate with the Library Association, the Museums Association, the Unions of Scientific Societies, the Further Education Section of the B.B.C., and such of the Educational Authorities that we can interest. That we plan a series of bi-annual or tri-annual booklets giving the outline of educational courses in the sciences, of sources of information for adults, and a guide for young people as to ways of entering the professions. This last I have mentioned earlier in this address.

By these means the Gateways of Science, both the way in for students and the way out for information, will be opened. The statutes of this Assembly define these things as part of our function; the channels for them are already in existence; and the authorities and the experts that could be used are in being. It is for us to supply the route maps for those who want to follow the scientific path. It is not for us to discourage the lone hand or to examine the childish ambitions. It may be tiresome for some; there may be a price, we may even have to create some form of corresponding membership for those who want the undoubted benefits and resources of this Association and yet cannot always find the ways and the means at the one week of the year when we all meet. These are problems that meantime must be left in the hands of the General Committee and of the Council who are used to large prospects and are not noticeably deterred by them. In creating such an organisation there will be difficulties; they will be surmounted. The service will grow from strength to strength; even in its early days it will benefit thousands; thousands, old and young, whose inability to be with us to-day is our loss and no fault of their own.

RADIO-ASTRONOMY[1]

by

J. R. SHAKESHAFT

Endeavour Prize Essay

EVEN before Marconi had succeeded in transmitting a short message by wireless telegraphy from Cornwall to Canada in 1902, Sir Oliver Lodge (1) carried out fruitless experiments with a coherer in a Liverpool shed to try to pick up radio waves from the sun. These pioneer efforts in Radio-Astronomy were not followed up until thirty years later when Jansky (2), investigating radio 'noise,' observed regular variations whose period was the sidereal day, indicating an origin beyond the solar system; the maximum being in the Milky Way. Grote Reber (3) in 1940 amplified these results by producing a chart of the intensity distribution and suggested the interstellar gas as a possible source of the radiation. The sun's emission was not in fact detected until 1942, when radar operators in this country reported serious interference, which Hey traced to a particularly large sun-spot then visible on the solar disc. Since 1945 we have a plain example of how the introduction of new apparatus and techniques can bring about advances in knowledge: the war-time research in radio receivers and aerials enabling the development of a fresh science, whose investigators are at present working in America, Australia, Britain, Canada, France, Holland, West Africa and even on a South Sea Island.

The radio 'window' in the earth's atmosphere extends from a wavelength of about 1 centimetre to 10 metres, being bounded on the low frequency side by ionospheric reflection and at the other end by molecular absorption. Two main types of aerial system are in use, the first of which is the 'pencil-beam,' analogous to the optical reflecting telescopes. One of these is being built under Prof. Lovell of Manchester University at Jodrell Bank Experimental Station, Cheshire. As the radio wavelengths are of the order of 1,000,000 times those of visible light, it is impossible to achieve resolving powers comparable with those of ordinary telescopes, but nevertheless by erecting a steerable parabolic reflector 250 feet across, a beam width of about 1 degree can be obtained. The second class includes the interferometers, which have a reception pattern filled with interference fringes as the radiation from the source along two separate paths becomes successively in and out of phase. This arrangement ensures better resolution for the small sources, but is not so good for large-scale structure. Among the interferometers are some in Australia working on the principle of Lloyd's single mirror, with the sea as a mirror and the aerial mounted on a cliff (4), and the twin-aerial type devised by Ryle and Vonberg (5) at Cambridge. Christiansen (6), also in Australia, has constructed a 32-element interferometer for a wavelength of 21 centimetres, similar in idea to a diffraction grating, each lobe having a width of only one-tenth of the sun's disc.

The signals observed take the form of small random fluctuations of amplitude, which are called 'noise,' and a consideration of the receiver sensitivity in the reception of these above the noise produced by the set itself, leads to the requirements of as great a receiver bandwidth and recorder time constant as possible. The requirements, however, clash with the desire to measure the variation of intensity with frequency, the difficulty of making interferometers for a large range of frequencies, and the occurrence of transients which need to be examined. Thus a compromise has to be reached, the ultimate sensitivity

[1] Essay awarded the first prize in the 1953 competition sponsored jointly by the publishers of *Endeavour* and by the British Association.

depending on the receiver noise. It is convenient to measure the intensities from given directions in terms of the ' equivalent temperatures,' using the Rayleigh-Jeans law, applicable at radio wavelengths, to change from one unit to the other. This is because the random noise is exactly similar to that produced by the electronic motions in a resistor connected in place of the aerial, this noise depending on the temperature. Even though the source may not be a perfect black-body radiator, we can still refer to an equivalent or effective temperature.

In our review of current work in Radio-Astronomy we shall first deal with the solar system, then the galaxy and the discrete sources. The solar radiation consists of several components which include a constant unpolarised background due to thermal emission from what is called the ' quiet sun.' The apparent temperature of this varies with the wavelength, since the longer waves come from the corona where the temperature is about 1,000,000 degrees and the shorter waves from the chromosphere close to the sun with a temperature between 10,000 and 100,000 degrees. The actual intensity of the quiet sun is difficult to measure at metre wavelengths because sun-spots give rise to enhanced radiation which may be some thousands of times as great, and also the solar flares can produce very strong ' outbursts ' increasing to a maximum within a few seconds, which may be correlated with magnetic storms and communication fade-outs on the earth. This extra radiation is often found to be circularly polarised, the direction of rotation being related to the magnetic field at the place of emission. At shorter wavelengths the enhanced radiation is less intense and alters less rapidly. Some of the recent observations deal with the exact location of sources of solar radiation and their connection with visible disturbances (6, 7) ; the distribution of brightness across the solar disc at different wavelengths (8, 9) ; and the occultation of the radio source in Taurus by the sun (10). These results increase our knowledge of the mechanism of sun-spots and flares, and lead to theories about the structure of the solar atmosphere. No really plausible explanation of the enhanced radiation has yet been advanced. The discovery of the centimetric emission brought forth the only suggested practical application of Radio-Astronomy, the United States Patent of G. C. Southworth (11) describing ' an apparatus for enabling artificial vision under daylight conditions of impaired visibility ' and advocating the use of reflected 1 centimetre solar radiation.

Piddington and Minnett (12) in 1949 directed a paraboloid aerial at the moon during a lunation and derived an average temperature over the disc varying sinusoidally about a mean of 239 degrees absolute. The amplitude and lag of the oscillations are best explained by considering the surface to be of some volcanic material such as pumice, covered by a thin layer of poorly conducting dust a few millimetres thick (13). These observations confirm measurements made at infra-red wavelengths. Other workers (14) claim to have detected the radiation from solar outbursts that has been reflected from the moon, and indeed several successful attempts have been made to obtain radar echoes from the moon using long pulses, but the return signals were only just discernible, so until the Jodrell Bank aerial is finished it may not be possible to reach any detailed conclusions about distance and reflection coefficient. With this new equipment reflections from planets might be strong enough to be detected and the time delay will give an accurate estimate of the dimensions of the solar system, thus correcting all astronomical distances which are founded on the trigonometrical base-line of the earth's orbit.

Our knowledge of meteors has been greatly increased by the efforts at Jodrell Bank ; Clegg, Hughes and Lovell (15) discovering the daytime streams in 1947. Using radio echoes from the ionised trails, the height and velocity of meteors can be determined, the orbits calculated, and the physical behaviour of the meteor trail studied. The vexed problem concerning the possible presence of meteors from outside the solar system was settled when none of the velocities measured were sufficiently great.

Since the first survey of galactic radiation by Reber (3), there have been others using wavelengths ranging from 10 centimetres to 15 metres, and employing

greater resolving power (16, 17, 18, 19). These show several features in common, notably a concentration of intensity towards the galactic plane and also towards the galactic centre. The equivalent temperature is found to vary (20) approximately as $\lambda^{2 \cdot 7}$, where λ is the wavelength; that at 3 metres towards Sagittarius, the centre of the galaxy, being about 6,000 degrees absolute. Calculations, assuming the sun to be a typical star, showed that the intensity due to all the stars in the galaxy fell short of that observed by a factor of 10,000,000, and so another mechanism had to be devised. Many papers put forward the view that this was the electron acceleration in the proton fields of the interstellar gas of ionised hydrogen, but the theory had to be abandoned, for, inserting the well-established datum of the temperature of the gas from optical astronomy (about 1,000–10,000 degrees absolute) we find that this only provides 1 per cent. of the required radiation at the longer wavelengths. Hence it seems that we must look for some class of stellar body with emission very much greater than the sun. Hey, Pearson and Phillips (21) in 1946 had already noticed that the intensity from the constellation of Cygnus showed rapid fluctuations, and concluded that there must be a source of small angular diameter in that direction. Once this lead had been given, interferometer type aerials were used to survey the sky, being specially adapted for examining small sources, and by 1950 the positions of well over fifty ' radio stars ' had been plotted, many of those in the Northern Hemisphere being listed by Ryle, Smith and Elsmore (22), who used a ' phase-switching ' method of much higher sensitivity than receivers measuring the total aerial power. This involves interchanging the maxima and minima of the interference pattern at a switching frequency of 25 c.p.s. Any source whose angular extent is small compared with the interference lobes then gives an alternating component at this frequency which may be amplified and recorded, whereas large-scale structure produces no such component. The declination may be found from the rate of passage of the source through the fringes, the right ascension from the time of transit and an estimate of the angular dimensions from the variation in amplitude as the aerial spacing is altered. This last may be compared with Michelson's stellar interferometer. It was rather surprising that at that date only seven of the radio stars were found to coincide with visual objects, namely, the Crab Nebula in Taurus, which is the remains of a supernova noted by Chinese astronomers in A.D. 1054; the Andromeda nebula (M31), M33, M51, and M81, all of which are among our neighbouring galaxies; and the two nebulosities NGC 5128 and M87 in the constellations of Centaurus and Virgo respectively. Especially remarkable was the fact that in the direction of the two most intense sources, in Cygnus and Cassiopeia, there was certainly nothing visible brighter than the 11th magnitude. The sources appeared to be distributed uniformly over the sky and no connection could be found with the nearest stars, the brightest stars, novae, planetary nebulae or clusters. The emission from the nearby galaxies was shown to be that expected if they had a background radiation like our own galaxy. In 1951 Westerhout and Oort (25) published an important paper showing that the 3 metre survey of the galactic background by Bolton and Westfold, could be explained by assuming that most of the radiation came from radio-stars, which are distributed both in mass and spatially through the galaxy in the same way as the common stars of types G and K, and they derive possible distances and brightnesses of these sources. The curves, however, could only be made to fit satisfactorily by substracting 600 degrees absolute from the observed temperature in all directions. This isotropic component will be mentioned later. It appears therefore that we must postulate a hitherto unknown class of star, emitting a great deal of radio radiation, which nobody has ever seen. It has been suggested that stars with high magnetic fields might be able to produce the required intensity and in addition, account for cosmic rays, which show a variation with sidereal time (27). Other authors (28, 29) regard the background radiation as due to the acceleration of cosmic-ray electrons in galactic magnetic fields of about 1/1,000,000 gauss, but they have to account for the presence of 10 per

cent. of electrons among the primary cosmic rays.

Optical astronomy makes wide use of spectroscopy, or the fact that each element can emit line radiation of characteristic wavelengths and it is reasonable to ask if Radio-Astronomy can do the same. It turns out (30) that there are several spectral lines which may be observable, notably one due to hydrogen, at a wavelength of 21 centimetres. Van de Hulst (31) in 1945 first suggested that the latter may be detectable, and it was picked up by Ewen and Purcell at Harvard in 1951. The 21 centimetre line arises in the hyperfine structure of the neutral hydrogen atom and the excited state has a lifetime of 10,000,000 years. Thus it is only in interstellar space, with densities of the order of 1 atom per cubic centimetre, that an excited atom can avoid collision long enough to lose its excess energy by radiation and only in regions the size of our galaxy that there is enough hydrogen for us to be able to detect the line. A preliminary survey (32) was carried out in Australia, but the potentialities of this powerful method were first fully realised at the Rome Congress of the International Astronomical Union in September 1952, when the work of Oort, Van de Hulst and Muller in Holland was described. The galaxy has long been thought to be of a spiral nature, very like the nebula in Andromeda, and since it can be seen there that O and B type stars are largely confined to the spiral arms, as also are the hydrogen clouds, attempts to locate the spiral arms in our own galaxy have previously involved complicated analysis of the distribution of these stars, but have not been made easier by the obscuring dust. The Dutchmen, in a few months only, by measuring the Doppler shift of the 21 centimetre line (due to differential galactic rotation) in various directions, have been able to plot out the positions of the hydrogen clouds and thus the spiral arms, and have finally settled the long controversy as to whether the arms were winding up or unwinding. They find the arms to be winding up, in agreement with Hubble's observations (33) but in contradiction to the theories of Lindblad and Milne. They have been able to determine the distance of the sun from the galactic centre as 25,000 light years and the rotational velocity of the sun round the centre as 230 kilometres per second. The great sensitivity of the radio receivers used in this work can be judged from the fact that the total power falling on the whole earth from this hydrogen line is about 3 watts.

Smith (34) at Cambridge and Mills (35) at Sydney have given accurate positions for the brighter radio stars, thus enabling Baade and Minkowski (36) at Mount Palomar, California, to use the 200-inch Hale telescope with such advantage that at present some fifteen identifications have been made. These fall into several classes with apparently one feature in common, large masses of gas in violent relative motion. It has already been mentioned that the Crab nebula is a source and it is found that the calculated position of the supernova observed by Tycho Brahe in 1572, though not now visible because of obscuring matter, emits radiation. Perhaps one of the main advantages of Radio-Astronomy is this ability of radio waves to penetrate the dust clouds which screen most of the galaxy from our gaze. New supernovae occur only every few hundred years in each galaxy and can contribute but a negligible amount of radiation to the background. The most intense source in the sky, that in Cassiopeia, is in our own galaxy, probably not further away than 1,000 light years and appears to be a nebulous bundle of hot filaments of a type previously unknown. Two of the other sources are similar to the Cassiopeia one, and then in the third class we have about six ordinary extra-galactic nebulae as already discussed. Lastly come four extra-ordinary ones. These are NGC 4486 in Virgo, which was noticed to be peculiar by the Lick Observatory staff in 1918, the source in Cygnus, NGC 1275 in Perseus, and NGC 5128 in Centaurus. The three latter are examples of galaxies in collision and in all cases at least one of the protagonists contains interstellar gas, which seems to be the prerequisite for radio emission. It is possible that the 600 degree absolute isotropic component of galactic radiation noted by Westerhout and Oort, while much too large to be due to the ordinary extra-galactic nebulae, could be explained

by integrating the contributions of all colliding galaxies. Optical measurements of the red shift of the spectral lines and the use of Hubble's constant (corrected for the error recently discovered in the distance scale) gives a distance for the Cygnus source of 200,000,000 light years, the velocity of recession at this distance being 16,700 kilometres per second, or $\frac{1}{20}$th of the velocity of light. Since this distance is $\frac{1}{10}$th of that to which the largest telescope can observe and the intensity from Cygnus is more than 1,000 times the minimum now detectable, a simple application of the inverse square law shows that some of the radio stars at present being mapped are perhaps farther away than man will ever be able to see. This startling conclusion is likely to be of the utmost importance to cosmologists, who want to have the largest possible sample of the Universe on which to test their theories. Van de Hulst (31) has shown that radio-astronomical data contradicts the Hubble-Tolman static theory of the Universe and it is not improbable that the more detailed surveys of radio stars in progress will lead to further identifications and possibly even a decision between relativistic cosmology and the steady-state theory.

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TRAINING FOR MANAGEMENT

by

SIR CHARLES RENOLD AND PROF. R. S. EDWARDS

AT the British Association's meeting in Liverpool, the Education Section devoted the morning of September 4 to a discussion on training for management to which the principal contributions were made by Sir Charles Renold of the Renold and Coventry Chain Co., Ltd., and Prof. R. S. Edwards of the London School of Economics. Sir Charles Reynold said that no apology need be made for discussing this subject as it was 'in the air' in two senses: it was very much in the public mind, and it was anybody's guess as to what should be done about it. Instead of attempting a general survey and reaching general conclusions he confined himself to one specific problem—that of the introduction of the University graduate into industry and his initial training there for managerial responsibility. He outlined a scheme of business training for graduates. Prof. Edwards dealt with much the same part of the field, and examined the proposed scheme of training with special reference to the task assigned to the Universities.

SIR CHARLES RENOLD

SOME GENERAL OBSERVATIONS ON MANAGEMENT

Approaching the matter from the point of view of an industrialist, I would first like to make a few general observations :—

In the first place I doubt whether, even to-day, the full significance of the role of management is appreciated.

We hear, for instance, that the chief need of British industry is for more science and more research. That may be, but it will not be met merely by increasing the number of scientists. If the contributions of science are to be put to work and bear fruit in industry, management must first provide the opportunities, the organisation and the procedures. The immediate bar to more science in industry is the failure to make full use of what we already have: it is a failure of management.

Take another aspect: the welkin resounds with exhortations for increased productivity and one gets the impression that this is chiefly a matter of improved operational techniques such as work-study and incentives. The informed manager, however, is only too well aware that the problem is not so simple as that. He knows that high productivity is inextricably bound up with high morale of the industrial unit.

A great deal of study has been given to this question of morale—to what makes people work effectively together — and what with the psychologists and the sociologists a considerable body of knowledge is available; but it is only management that can put that knowledge to work and make it bear fruit in practice.

Then again, think of the bewildering jungle of economic trends and forces throughout the world, a correct appreciation of which may well determine the individual company's chance of success. There is no lack of economists to help to map the jungle, but unless management can read their maps and discern their meaning for their particular affairs they remain merely sad records of all that industry did wrong.

The point I want to make is that it is not absence of knowledge and information that limits the progress of industry but the inadequacy of management to appreciate and put to use what is in fact available. Indeed the very plethora of such knowledge and information is itself a difficulty. To keep *au courant* in so many fields is daunting enough, but to combine the ability to do so with the ability to do

something practical about it—to put the knowledge to work—is a severe challenge to management.

Here is reason enough for the concern about improving the calibre of British management. That is the crucial factor on which the future of British industry depends. It is the realisation of this that is leading industrialists more and more to look to the Universities for recruits.

I have so far spoken of ' management ' in very general terms, as though it were a homogeneous activity. This is not, however, the case. Management comprises a great variety of fields of activity, each concerned with some specialised function and each with its own highly developed techniques and specialised knowledge.

These include such specialised functions as planning, costing, purchasing, personnel administration, market research, design and development, work-study, production control and a host of others. Each of such specialised activities is in the charge of a section of the management.

General Management

But there is another management activity that consists of co-ordinating all these specialised activities into an organic whole and directing that whole as a combined operation. This is ' general management.'

As the specialised branches of management multiply and develop the task of general management becomes ever more exacting and it is in this field that the need for people of higher calibre is greatest.

It is in regard to this field too that the problem of training the succession presents the greatest difficulties. This is not only because the combination of qualities of character, education, and experience that are required are comparatively rare, but also because the candidates for general-management responsibility must, almost of necessity, be sought amongst those who have made their way up one or other of the specialist management ladders. And, on account of the ever intensifying specialisation, those activities do not provide the natural training ground for *general* management that they did when business was simpler.

In thus highlighting the importance and the difficulty of raising the calibre of General-Management I am not underrating the importance of the specialist fields of management.

It is, of course, vital that all these specialists should be well qualified and well trained, but the qualifications are, in the main, technical ; the provisions for education and training are well established and the flow of such trained specialists is fairly adequate. Indeed it is largely the very progress made in these specialist management technologies, and in the teaching of them, that has thrown into prominence not only the need for raising the calibre of General-Management but the difficulty of doing so.

I have stated that the provisions for producing specialists are fairly adequate, but in view of the fact that General-Management has to be recruited, almost of necessity, from amongst the senior management specialists, this statement needs qualifying. Present schemes for training such people can only be considered adequate if it is accepted that the aim is limited to producing specialists. But such an aim is too narrow. The aim should surely be to produce people who are not only competent in their own special field but who have a sound appreciation of the management picture as a whole and of the part which their particular specialism plays in it. There is therefore a need to broaden the present education and training schemes in the various management specialisms.

The Initial Training Period

With these preliminaries I will plunge into my subject—what to do with University graduates on their entry into industry.

The first point is that any Company that makes a practice of taking in graduates should not leave their training to chance ; there should be a well thought out scheme for dealing with them. I have in mind that it should cover a period of some three years.

A Company's graduate trainees constitute a pool of talent from which it is hoped that future leaders, both in specialist fields and in the field of general management, may be developed. With this in mind I suggest that the objectives of the training scheme are threefold :—

(1) To give the graduate the 'feel' of industrial life; to accustom him to its disciplines, its people and their modes of thought; in short, to help him to find his feet.

(2) To give him a general understanding of the basic features of the Company's business—technological, commercial and organisational.

(3) To give him the opportunity to 'develop' so that the particular bent of each one may be revealed and the foundations of specialised knowledge and experience be laid that the development of that bent will require.

It will be noted that I have not included amongst the objectives at this stage learning to carry responsibility and to exercise authority. I am well aware that it is one of the most frequently voiced grievances of graduate trainees that they are not given responsibility and many of them attribute a sense of frustration to this lack.

This complaint implies, to my mind, some loose thinking. 'Responsibility' means, in this context, being answerable for results. 'Authority' means the power necessary to fulfil the responsibility. Now responsibility proceeds by stages. It begins by answerability for results in a field in which oneself is the sole performer: it proceeds to answerability for the results of a group of people. It is only at this latter stage that authority comes into question.

Applying this to the graduate-trainee: it is important that as much as possible of his training should consist of doing specific jobs rather than of mere looking on. And for the performance of such jobs he should, of course, be held responsible. But learning to be responsible for the work of others, and to exercise the authority required therefor, seems to me to be a matter for a later stage, after the trainee period is over.

The Objectives Examined

Let me examine these three objectives more closely.

The first concerns the transition from the atmosphere of the University to that of Industry. This transition calls for a drastic re-orientation of the graduate's attitudes of mind and sense of values. Thus: in the University knowledge is valued as an end in itself; in industry as a guide to action. In the University the problems to which the student's mind is directed are capable of solution by academically acquired knowledge and method; in practical life other elements, often intangible, enter into the solution as well, and often predominate in importance.

Again: in the University the academic work is in the main individualistic, each student is studying for his own ends: in industry no one's position or work has significance except as it contributes to what is essentially a combined operation. Combined operations require the observance of disciplines that are not required in University life and their acceptance is not easy. Perhaps the greatest re-orientation concerns the time factor. In the University approach to knowledge the pursuit is to the bitter end—to complete fullness of understanding: in industry the emphasis is always on a time-table. Time is of the essence. Decisions, to be of use, are required by a certain time and they have to be made on as much information as is then available, whether or not the search has been fully exhaustive.

The contrasts could be multiplied almost indefinitely but enough has been said to indicate the severity of the readjustment of attitude that the University graduate is required to make when he first enters industry. One of the objects of a training scheme should be to ease this transition by helping the new entrant to understand what goes on and the reasons for it and to acquire the habit of working to instructions and to a time-table as a unit in an organisation.

The second objective—becoming acquainted with the basic features of the Company's business is, of course, obvious. If these people are some day to occupy leading positions in the Company they must have a sound appreciation of its fundamental problems, both technological and commercial, and a grasp of its organisational structure and main policies. This seems to call for some change of systematic teaching which itself should be thrown against a wider background of instruction about industry generally. It is in this connection that co-operation with

the Universities, to which I am leading up, arises.

The third objective involves more difficult points. The graduate training scheme should fit a man, by the time he has completed it, to take on some real job in the Company. Hence the graduate should, during the course of his training period, make up his mind as to the special field of activity to which he is attracted and the latter part of his course of training should be shaped in that direction, both as regards experience and special study.

The Problem of Specialisation

This need to specialise introduces difficult considerations. It has been pointed out that the most pressing need, and the one most difficult to meet, is to train future leaders in the field of general management. Now, the essential qualities for general management are a wide knowledge of the business in all its aspects, plus a maturity of experience, judgement and habits of command.

Thus the field of general management really only begins at a comparatively high level and the necessary maturity has to be acquired in one or more of the specialised fields of activity, because the general management field cannot, in the nature of things, provide its own ladder of experience from the bottom upwards.

We are thus faced with this dilemma. The greatest need is to improve the calibre of general management. The pool of graduate trainees should contain potential general managers, but the training in carrying responsibility in ever widening spheres can only be obtained in one or other of the specialist activities. It is only in those fields that a real job of work can be offered to the ex-trainee.

But if the specialism becomes too obsessive it may well develop an outlook too narrow for ultimate transfer into general management. Thus, whilst the foundations of a training for general management can be laid during the training period by giving the trainee a picture of the Company and its activities as a whole, the discovery and development of capacity for general management responsibilities is a matter for later years. This is one reason why it is essential for a Company to make arrangements to keep under continuous review the progress of its staff of all levels and all stages, in order to spot talent and latent capacity wherever it can be found, and to arrange transfers and promotion with a view to its development.

A Free Field for Promotion

This is a convenient point at which to enter an important caveat. University graduates are not the only source of potential General Managers. The inherent qualities of character are, of course, also found in others and it is fatal to the morale of an organisation if it is believed that there is no chance of promotion from the shop floor. There must be no ' officer class,' recruited as such and having a prescriptive right, from the outset, to the top jobs.

This reinforces the point already made, viz. that the search for, and development of, managerial talent within an organisation should be systematic and apply to all grades and there should be arrangements to transfer into the graduate-trainee stream people who entered by other doors.

Having said this it nevertheless remains true that the potentialities for general management ought to be highest amongst the University graduates, on account of the process of educational selection that took most of them to the University and the intellectual disciplines to which they have been subjected. There is thus a clear case for the intake of University graduates by an industrial concern not only in view of the scientific and technological contributions that they can make but also as a source of potential candidates for general management.

The Danger of Frustration

This brings me back to the particular problem of this paper—what to do with the University graduate when he enters industry.

Before discussing actual schemes of initiation and training it will be well to consider the real nature of the problem and its difficulties. These lie, I think, in the lopsidedness of the graduate's equipment for life. He has spent long years of study in preparation for playing a real part, but on entering industry he finds

himself still separated from a real job by his lack of practical knowledge and experience. And during the process of acquiring these his theoretical knowledge and his intellectual capacities seem hardly to be called on. He may well find himself amongst people who are intellectually his inferiors and who yet seem adequate to hold down the practical jobs. Having, at this stage, little or no opportunity to put his intellectual attainments to work he may well wonder whether they were worth acquiring or, indeed, whether industry does offer a career that can satisfy an educated man.

In other words the main difficulty is to avoid a sense of frustration arising during the first few years in industry.

This difficulty is not, however, confined to the period of the initiatory training course ; it may be even greater in the following few years. Most graduates realise that before they can hope to hold down a real job that will call for the full use of their intellectual capacities they have to learn the ropes, and that learning the ropes is apt to be a humdrum process. But to find that even at the end of the initiatory training course—after all that preparation—the prospect of being entrusted with any management responsibility is still remote may well damp the most enthusiastic spirit. It is hard for him to realise that, with all his education and training, he has only arrived at the foot of the ladder that leads to management jobs, where others without his qualifications arrived at an earlier age.

The truth of the matter is, of course, that the value of the educational and training preparation is not that it starts a man off half way up the ladder but that it should enable him to climb it faster and further. This is a hard lesson to learn and the highest casualties from frustration undoubtedly occur during the first few years after the training period when a man is climbing the lower rungs.

It should, perhaps, be pointed out at this stage that this problem of frustration is greatest in the case of the Arts graduate. The case of the engineering, chemistry and other science graduates is less difficult since, after the initiatory training period, he can usually be assigned to some technical job in which some at least of his educational attainments can forthwith find application. The Arts graduate has, however, much more lee-way to make up before he can pull his weight in practical activities in industry, and the period before his more general educational attainments can come into their own is longer. The problem of coping with this long period, avoiding his becoming a victim of frustration in the meantime, is still somewhat baffling.

Co-operation between the Universities and Industry

I would now like to return to the first stage of the process of training—the initiatory course.

The general aim of such a course is to place the trainee at the end of it in a real job of some kind, with his foot on the ladder—or rather on *a* ladder—usually with managerial responsibility as the goal. I have already indicated three component objectives within this general aim, viz :—

(1) To give the trainee the feel of industrial life and to help him to find his feet.

(2) To grasp the general features of the particular Company's business.

(3) To help him to ' grow on ' and to reveal his particular bent and to acquire the foundations of knowledge and experience for a career based thereon.

The usual plan is for a Company to run its own training course. The conception of such courses varies greatly. At the one extreme they include definite tuition in the work of the Company, external part-time study, a well-planned scheme of moves through various departments and the whole under careful supervision. At the other end of the scale, some Companies merely take in graduates and give them the run of the place through various departments and let them pick up what they can by looking on at what is being done.

The latter plan simply invites frustration and has almost nothing to be said for it. The former may be very good, but it is difficult for any but a really large Company to operate effectively.

The suggestion that I desire to explore is that the University should co-operate with industrial Companies in running joint training schemes, each party making

the contribution for which it is particularly fitted. The main elements of such a scheme would be as follows :—

(1) The whole course would extend over three years.

(2) The trainees would be engaged by their Company at the outset and their attendance at the University would be as sponsored students.

(3) The three years would be spent partly with the Company and partly at the University, in each case on a whole-time basis for the time being.

(4) The Company's part would be to give the trainee the feel of industrial life and its disciplines, basic knowledge about its products, processes, markets and organisation, and experience in a range of jobs. In the course of this the trainee's particular bent should reveal itself and the programme of experience should then be adjusted accordingly.

(5) The University's part would be twofold, viz. :—

(*a*) To give the trainee a background understanding of industry which would illumine and give point to his practical work, thereby making the latter more speedily effective as training.

(*b*) To give him more specialised knowledge in the fields in which he is, from the point of view of his chosen career, deficient.

Subject to the field of the trainees' undergraduate studies, the background would embrace economics, industrial history, commercial law, company financial structure, operational organisation and management. These studies would not be directed to proficiency in particular fields or techniques but to making the student aware of the nature of the forces that shape industry and of which account must be taken by those responsible for its leadership. Towards the end of the course some specialisation may be desirable when the trainee's particular bent has begun to reveal itself.

The distribution of the three years as between Company and University would call for careful consideration and would no doubt have to be adapted to University time-tables. In any case the start should be with the Company and that period should be sufficiently long that the trainee, when he then proceeds to the University, would have some idea of what he is looking for. As a cock-shy I suggest the following time-table :—

First six months—with the Company, in two or three departments only, with systematic lectures on the main features of the Company's business.

Next nine months—at the University spent on industrial background subjects, and in the case of the Arts graduate an appreciation of the technology of his chosen industry.

Next six months—with the Company continuing his round of departments, with an emphasis on some particular section of the business according to the trainee's bent.

Next nine months—at the University—spent on more intensive study of a limited range of subjects according to the trainee's bent, but in any case including management.

Last six months—with the Company in the department indicated by the trainee's bent, beginning to get to grips with the details of its work.

It may be objected that the above time-table envisages too great a proportion of full-time University work and too little practical training with the Company. This objection could be met by a modified time-table which, though to my mind less good, would still embody the basic conception. Thus the first period of full-time University work might be omitted and the background education which it is intended to provide might be met by guided reading and part-time attendance at selected evening or day courses at the University, during the trainee's first period with the Company.

Such an alternative time-table might work out as follows :—

First fifteen months—with the Company going through a fairly wide range of departments, with systematic lectures on the main features of the Company's business *and* with guided reading and part-time attendance at lectures on background subjects (or in the case of the Arts graduate possibly on the technology of his chosen industry).

Next nine months—at the University on a post-graduate management course.

Last twelve months—with the Company in the department indicated by the trainee's bent getting to grips with the details of the work *and* with guided part-time day or evening attendance at lectures dealing with his chosen field.

I am convinced that at the end of a programme on either of these lines the trainee would be found to be ready to hold down a real job and to take his place on some ladder with obvious prospects of promotion and with a high degree of understanding of what it was all about.

I am convinced, furthermore, that by no other means could the trainee be brought to such a level of maturity in relatively so short a time and, hence, that such a scheme may legitimately be commended to industry as a means of saving time in bringing the potentialities of the University graduate to the stage of effective performance as an employee *en route* to management.

Prof. R. S. Edwards

Sir Charles Renold has outlined a scheme of business training for graduates. I propose to devote my paper to an examination of that scheme and more especially to the job assigned to the universities.

Sir Charles envisages that the trainee would spend at the university two periods of nine months each. In the first period he would study industrial background subjects, and, if an Arts graduate, acquire an appreciation of the technology of his chosen industry. In the second period he would make a more intensive study of a limited range of subjects including management. These academic spells would be preceded, separated and followed by spells of practical training in the firm itself. An alternative time-table involving only one nine-months spell of academic work is also put forward and I will come to that later.

I

Let us first consider whether the universities could cover the syllabus. I see little difficulty in the curriculum for the first year on industrial background subjects. Economics, economic developments, financial organisation, the economics of labour, the structure of industry, elements of English law, industrial history, the elements of statistics and accounting—all these could I think be provided by most universities in the course of their normal work.

A course for Arts graduates on the technology of the chosen industry is a more difficult problem. The graduate trainee certainly ought to make a real effort to grasp the main lines of the technology on which the work of his firm depends; but if technology here is narrowly defined he might best acquire knowledge of it within his own firm supplementing his study in suitable cases by attendance at a technical college specialising in that technology. On the other hand, if Sir Charles has in mind something wider, such as an attempt to give the trainee a broad introduction to industrial materials and products, manufacturing processes and equipment, and some appreciation of developments in science and their application to industry, then I believe myself that there is here a task which the universities might tackle. Indeed the Imperial College of Science and Technology is already experimenting with a course on these lines for the postgraduate students of the London School of Economics. It may be that similar courses are being tried in other universities.

It is the curriculum for the second academic spell that will raise the biggest issues and it is on this that I shall therefore concentrate my attention. Sir Charles says that this curriculum must include management. The first task then is to review the postgraduate facilities that already exist in this country and to consider the problem of expansion and development.

There are two one-year university postgraduate courses in business management which were established before the war. One is offered by the Department of Industrial Administration in the Manchester College of Technology and includes the elements of economics, history of industrial organisation, industrial relations, industrial law, industrial management, purchasing, storekeeping, transport, work measurement and wage systems, statistical method and factory costing. The other is offered by the Department

of Business Administration of the London School of Economics. The curriculum there includes business administration in the light of economic analysis, industrial production and distribution, business finance, industrial relations, personnel management and methods of wage payment, the law relating to business, management accounting, business statistics and market research. It also includes the Imperial College course already mentioned.

In addition to these courses there has, since the war, been a development of postgraduate courses in technology, in one or two of which management subjects are included. Thus, the Department of Engineering Production at Birmingham University, in association with the Faculty of Commerce and Social Science, gives a course which embraces the principles and practice of engineering production and industrial management. The Royal Technical College, Glasgow, offers a one-year postgraduate course in Production Engineering. Birmingham also offers a Graduates' Commerce Diploma as an introduction to the methods and problems of industrial administration and commercial organisation.

These university facilities were, in the main, established in anticipation of just such a demand from industry as Sir Charles' scheme envisages. They would enable a considerable experiment to take place immediately and given time they could be developed and expanded and new courses could be started. I say 'given time' advisedly; no one should imagine that the staffing requirements for courses in management are light or easily met. It will give some idea of what is involved if I say that the L.S.E. course—which takes about twenty students each year—is run by seven Professors specialising respectively in Business Administration, Industrial Organisation, Labour, Business Finance, Accounting, Commercial Law and Industrial Law, three Readers specialising in Distribution, Cost Accounting, Statistics and Market Research, and four lecturers. No member of the staff is full-time on the course, but for most of the fourteen it is a significant part of their work and for Sir Arnold Plant, who is responsible for the course, and one or two others the burden is substantial.

If universities are to offer this range of specialisms at the standard they maintain in other fields—and it would be calamitous to adopt a lower standard—expansion will have to be steady rather than rapid. It should, however, be possible to keep pace with industry's requirements, even if to do so involved some temporary modification in teaching methods—a matter to which I will return.

II

We must next ask ourselves whether, given that the facilities exist, it is worth while for firms to release their trainees for academic work, as Sir Charles suggests; whether, looking to the long-term development of the trainee, this period of postgraduate academic study is likely to be a better investment than if it were spent in the firm itself.

This is a complicated question which has been bedevilled by arguments about whether management or administration can be 'taught.' In the sense that only practice and experience can give skill in anything and that, at the highest level, natural ability will play a very important part, no person can 'teach' another to be a first-rate administrator—or for that matter a first-rate engineer, musician or painter. But that is very different from saying that nothing which improves a person's understanding of administration, and therefore his speed of learning and his proficiency, can be taught. For this would be plain nonsense; it would put administration in a different category from every other art; it would imply that nothing of the lessons learned by one generation could be passed on to the next.

The real issues concern the type of trainee and the advantages of concentration and specialisation in teaching. As to the first, I do not believe that all graduate trainees should be released for academic courses. Some young men would be best advised to carry straight on with the practical job; they may be potentially good administrators but are not the type to gain much more—at least at this stage—from further academic study. For others, postgraduate academic training may be profoundly important. It will never be possible to sort trainees into those who would

gain and those who would not with complete certainty, but in practice I am sure that university teachers and employers would between them be able to offer the right advice in most cases.

As to the second point, it is always possible that a young recruit to business may find himself in the hands of men who are good administrators, who have sufficient understanding to be able to expound the 'why' as well as the 'how,' and who have the leisure in which to do this. It can and does happen but, by and large, training schemes which include a systematic academic course of study are likely to develop an understanding of administrative problems more rapidly, and often more surely, than those which rely on practical experience alone.

A much more debatable issue concerns the stage at which the course of study should be taken. Many subjects are easier to grasp after the student has had some experience of the phenomena with which the subjects are concerned. Some people would take the extreme view that it is quite useless to study business administration until one has had experience of it. I think myself that the weight of evidence is against this extreme view. The majority of young men who go to the Harvard and other American Business Schools are without experience. They come straight from college. I believe that most people with actual experience of teaching in the business administration field would agree that, even without prior practical experience, it is possible for mature students who are good observers and who make effective use of analogies to gain something and perhaps a great deal.

Nevertheless, there is no question that the task of learning (and indeed of teaching) is greatly eased if the student has already had some experience of business life, and it might be asked, therefore, why university schools of business do not make several years' experience a condition of entry. The answer is, I think, that if they did they would not get the students. Business firms find it very hard indeed to part with able men, and able men with a foot on the ladder think twice before stepping back into academic life.

It is precisely because it should help resolve this difficulty that I am attracted by the proposal outlined in Sir Charles' paper. Because the academic work would be an integral part of the traineeship but not the first part, the trainee would have had at least a little experience of business in action though not sufficient to have settled down in a job his release from which would be embarrassing.

III

We must next ask whether these mixed practical and academic traineeships would be desirable from the university point of view. There are still some people who would argue that, even if business administration is 'teachable,' the university is the wrong place for it to be taught. I must confess that I have always been puzzled by this view. Let us consider for a moment what a study of administration really involves. First, it must include an examination of the legal, political, economic, social and technical forces which bear upon the type of organisation being studied—in this case business organisation. Secondly, there must be an analysis of the problems of defining objectives, of planning, of co-operation, and of authority. Thirdly, there must be an introduction to the tools of administration—committees, budgets, statistics, accounts and so on—which are used in the formulation of objectives, the execution of decisions and the review of achievement.

'Society requires of the university graduate,' says the University Grants Committee in its latest report 'much more than his degree, or his expert knowledge of a particular field. It also requires the breadth of outlook necessary for those who are to fill positions of responsibility, and a university cannot be said to have risen to the height of its obligations until it has so designed its teaching as to ensure for all its students who use their opportunities the chance to become, in the words spoken by J. S. Mill more than eighty years ago, "capable and cultivated human beings".' Judged by this test the potentialities of business administration as a university discipline are high—considerably higher than those of some other subjects that have long found a place in the university curriculum. Well taught it will afford practice in rigorous analysis, in

weighing evidence, in spotting inconsistencies, in distinguishing value judgments from facts and truth from falsehood. There is evidence of a growing recognition of this. The U.G.C., in the report from which I have just quoted, considers 'that there is a useful field for universities in developing research and postgraduate teaching in those academic subjects, such as industrial relations, applied economics and applied statistics, which are also the tools of management'. It is the integration of these that makes of business administration a university discipline.

IV

May I now touch on an important pedagogic problem? How does one bring students with different first degrees on to a common plane of discourse? Graduate trainees may have read science, engineering, law, economics, history, languages or any other subject. These subjects differ from one another in the foundation they provide for a postgraduate course in business administration. A graduate in economics is likely to know a good deal more about industry and trade than a graduate in archaeology.

This is a real but not an insurmountable problem. It is not as though the university postgraduate course aimed to produce an *élite* of professional administrators—which would be a nonsensical thing to try to do. Rather does it seek to give men of different backgrounds and different skills an insight into the way organisations work. In short it seeks to parallel academically what happens in life, where all supervisory work calls for a balance of technical and administrative skill, the proportions varying from job to job. It would be the very negation of this task to say that it is possible for trainees with one background but not others.

One of the merits of Sir Charles' scheme is that it would allow the trainee a whole nine months in which to acquire the so-called background subjects. Moreover, in two academic postgraduate years some trainees would be able to take a master's degree if they so wished. Unfortunately, however, the timing would not fit the university year. If a graduate took a month off to recover from his final examinations and entered industry in, say, August, he would have finished the first spell of six months' practical training by the following February. No university would be likely to put on a nine months' course starting then. The real alternatives are to provide short courses in the summer term, which I do not think universities would welcome, or to lengthen the first spell of practical training and, in consequence, the whole course of the traineeship, or to cut out the first period of full-time academic work and replace it by a scheme of reading and lectures spread over the first year to fourteen months (depending on when the trainee started) which would be spent in the firm itself. This third possibility is virtually the same as Sir Charles' alternative time-table.

It would be quite practicable. At the beginning of the traineeship the employer firm, the trainee, and the university to which he would be going, could confer together and a programme of guided reading could be worked out and supplemented as need be by lectures attended in the evening or by day release at a local university or technical college. Not only would it be practicable but I suggest that it might for many trainees even be a more desirable arrangement. In the first place, a year to fourteen months' *continuous* work in industry might give a better appreciation of industrial life and its discipline than two periods of six months broken by nine months away at the university. Secondly, if the trainee was made of the right stuff it would certainly not hurt him to devote evenings and week-ends to study during his spells of practical training. And thirdly, the period of military training gives to many young men an opportunity for study and gives to all an incentive to concentrate their business training once they have made a start.

Hence, although there will be exceptions for whom two years in academic life would be desirable and possible, I would be inclined to plan in general for traineeships that included nine months of full-time academic work preceded by one year to fourteen months of practical training and followed by a further spell of practical training, the length of which I suggest would vary according to the firm and the trainee.

V

Since this is the Education Section of the British Association perhaps I may now say a word or two about teaching methods for the academic part of the traineeship. I doubt whether it is possible to lay down any hard and fast rules. So much depends on the number of the students, their ability and maturity and on the qualities of the teacher. But at the postgraduate level, it is clear that as much initiative as possible should be passed to the students and that discussion classes or seminars rather than straight lectures should be the normal practice. Nevertheless it would be wrong to make a fetish of any particular form of working. Sometimes lectures secure economy in working without any loss of understanding, and when they do why should they not be used?

In the L.S.E. course, which is the only one of which I have working experience, discussion is the usual method, the material for discussion being mostly drawn from the actual problems and practice of business. But here also I see no advantage in making a fetish of the case method if that means using problems or situations exactly as they occurred on a particular occasion. One may want to give a problem a slightly different slant or alter a situation a little to drive home a particular point. If one knows one's subject, one knows the kinds of situations that occur and the kinds of problems that have to be solved, one knows in how many different guises they will be found and one knows how far to synthesise without losing touch with reality. If one does not know this, then I doubt whether the mechanical reliance on case studies will help. For the snag about case studies—a snag which makes me suspect the usefulness of their large-scale collection by relatively junior or inexperienced persons—is that they must be torn from their context. No case can ever be detailed enough or profound enough to tell the whole story, and it is the problem of taking the case out of the context that is the most difficult aspect of case collecting.

One of the most effective ways of using case material is to handle it comparatively. Let me give two examples. The pricing of products raises most complex questions and provides excellent material for taxing the intelligence and developing the understanding of the student. In the L.S.E. course these questions are thrown up and studied by taking a series of examples of the way in which actual firms undertake the task. Sometimes the reasons for the differences in their practice are clear, sometimes they are not but can be discovered by discussion and inquiry. Learning in this way, the student can continue in after-life the practice of analysing for himself the similarities and differences which each new case presents when compared with those already within his experience. Or to take another example: the perennial problem in large organisations of securing the best balance between centralisation and decentralisation. By taking one function, say purchasing, and studying what happens to it in businesses of comparable size one may find that in the one case the operating units are left free to make their own purchases or to co-operate as they like, in another the centre appoints a functional specialist and leaves to him the decision as to how much work to decentralise. The attempt to discover and understand the reasons for the differences and to judge of their wisdom is excellent training. Incidentally, it illustrates both the possibilities and the limitations of the case method. It requires from the teacher a considerable acquaintance with the history and organisation of, and the *personalities* in, the firms concerned.

But, says the sceptic, British industry will not give you what you need; it is too secretive. Clearly there are some things which firms will not and cannot be expected to disclose, and there are others that they will not disclose if they are asked in a flat-footed way. But in our experience at L.S.E., of all the problems that there are to worry about, the supply of case material is the least. Industry and also, let me say, the civil service are most co-operative. As evidence of that I may mention the weekly evening seminar in which businessmen, civil servants, teachers and postgraduate students meet together. Practically all the papers for that seminar are given by businessmen or civil servants. There have been about 150 over the last seven years, many written by men and women of great distinction in business or public life. Apart from the discussion

which they stimulate, the papers, which are available to each succeeding group of students and some of which are being expanded by co-operation between the firm concerned and a member of the academic staff, form a steadily-growing source of information and opinion.

What teachers of business administration *are* short of is not case material but good analytical studies. There are plenty of books on business techniques but few that integrate satisfactorily the study of the various functions in business or which examine the machinery of management within the setting of policy.

This, I think, is really the limiting factor on the speed at which postgraduate courses can be developed. I am sure that it is important that business administration courses should be closely linked—and indeed more closely linked than is usually the case in America—with the established disciplines, economics, law, political science, etc. But if one wants to attempt that synthesis which makes business administration a discipline in its own right, rather than a number of snippets from other disciplines, one has to move forward slowly, for the labourers in this particular vineyard are few, and they need a combination of characteristics not easy to find.

VI

However, as I have said earlier, I believe the universities could match any likely level of demand for postgraduate training in business administration. At present there are few businesses in this country which release their men to take postgraduate courses. We are not at the stage where the number of good quality applications from this country exhausts the facilities available. There is adequate room for a major experiment on the lines that Sir Charles suggests. If a number of leading firms tried it and were satisfied and, in consequence the demand for places increased rapidly, we should face the problem of expanding existing facilities and developing new ones. We might find that for a time we could not meet all the demand. If that happened it would be the better course, in my judgment, to dilute temporarily the discussion method of teaching with more lecturing rather than to establish new departments and additional posts and man them at a level below what is regarded as appropriate to university work in this country.

Although I hope that this is a real problem for the future it is not a real problem for the present.

I would like to see thirty to forty leading businesses, each second to a university postgraduate course in administration one trainee in each of the next three academic years. Industry could then judge for itself whether or not an academic year during business training is worth while. We shall never settle this matter just by discussing it.

I should hope that there were enough large firms to whom this matter was sufficiently important for them to think it worth financing the sponsored students wholly at their own expense. But encouragement helps, and I should therefore like to throw out this suggestion in the hope that it may catch the eye of those responsible for using the counterpart of the dollar funds put at the disposal of European Governments by the Americans under the Benton-Moody Amendments. I know that most of these funds have already been allocated but I see that there is a reserve the use of which is not yet decided. The Americans believe in postgraduate business courses. Would it not be an imaginative gesture, and one very much in accordance with the spirit of the Amendments, if firms seconding men for postgraduate business training in European universities were to receive from these funds a grant equal to half the salary of each man accepted for a course? If this contribution gave the scheme a good send-off it would be money well spent.

VII

Before I conclude there are two more points I want to make. The first concerns the non-graduate. The road to the top must be open to all comers and therefore I would propose that the scheme of seconding men to a university postgraduate course should not be limited to graduates. It has been our experience at the L.S.E. that a non-graduate between twenty-five and thirty years of age, who has been marked out for managerial responsibility, and also may have taken professional qualifications

in engineering, accounting, etc., in his spare time, will often mix very well indeed with a graduate group and will profit enormously from a year spent in this way.

My last point takes me back to the beginning. Sir Charles and I have concentrated on one field of business training. But I hope that we shall not leave the impression that there is anything exclusive about the proposal put forward. Management training is needed at all levels and there is room for many different kinds of experiment. We have, for example, said nothing about the Administrative Staff College, Henley, where three-months' courses are taken by men and women in early middle life. I believe that this type of course is of very real value and that the demand for it will grow. A short period out of the line, so to speak, and in quiet surroundings, exchanging experience and ideas under skilled leadership, is a refreshing and often exciting experience. But postgraduate training and the Staff College course are not alternatives. Indeed the development of the former will I am sure lead to an increased demand for the latter.

VIII

If I may sum up in a sentence or two. I believe that the principle of the scheme outlined by Sir Charles is right and that the universities working in this field would willingly co-operate with industry. I believe that the scheme itself could in general be concentrated so that the full-time academic course would take only nine months. I would hope that sufficient of Britain's leading industrialists would back the scheme to give it a real trial and that, to stamp it with official blessing, some of the funds provided by the American Government under the Benton-Moody Amendments could be made available to help finance the trainees accepted for university courses.

LIVERPOOL MEETING

SECTIONAL TRANSACTIONS

Any references to publication supplied by authors will be found on page 320.

SECTION A

MATHEMATICS AND PHYSICS

September 3

Prof. J. M. Meek.—*The mechanism of lightning discharges.*

Mr. B. J. Mason.—*The generation of electricity in thunder clouds.*

Dr. S. Whitehead.—*Recent developments in dielectrics.*

September 4

Half a century of geophysics, Presidential Address by Prof. Sir Harold Jeffreys, F.R.S.

Magnetic properties of the earth's interior :

Sir Edward Bullard, F.R.S.—*The magnetic properties of the earth's interior.*

Prof. A. T. Price.—*Periodic and irregular fluctuations of the earth's magnetic field.*

Mr. J. Hospers.—*Repeated reversals of the main geomagnetic field.*

Dr. F. J. Lowes.—*Some implications of a thermoelectric theory of the geomagnetic field.*

September 7

Advances in underwater observation.—See entry under Section D.

Nuclear physics researches at Liverpool :

Prof. H. W. B. Skinner, F.R.S.—*Particle accelerating machines.*

Dr. W. H. Evans.—*The diffusion cloud-chamber.*

Dr. K. W. Allen.—*Methods of detecting fast particles.*

Dr. K. J. Le Couteur.—*The nuclear shell model.*

Dr. J. R. Holt.—*Nuclear distintegration by deuterons.*

September 8

Cybernetics.—See entry under Section J.

Prof. J. Proudman, F.R.S.—*Liverpool work on the offshore distribution of tides.*

Mr. J. R. Rossiter.—*The North Sea storm surge of January 31–February 1, 1953.*

Dr. H. D. Parbrook.—*Acoustical design in ecclesiastical architecture.*

Mr. H. J. Purkis.—*Acoustics of the Royal Festival Hall.*

September 9

Dr. A. V. Crewe.—*The measurement of magnetic fields.*

Prof. H. W. B. Skinner, F.R.S.—*The soft X-ray spectroscopy of metals.*

SUB-SECTION A*

MATHEMATICS

September 3

Dr. L. Mirsky.—*Recent advances in the analytic theory of prime numbers.*

September 5

Exhibition of calculating machines.

September 7

Prof. L. Rosenhead, F.R.S.—*Society and the calculating machine.*

Dr. A. Fletcher.—*Mathematical tables, past and future.*

Mr. A. Young.—*The use of punched cards in science and administration.*

SECTION B

CHEMISTRY

September 3

A suggestion and some consequences, Presidential Address by Prof. G. R. Clemo, F.R.S.

Sir Robert Robinson, O.M., F.R.S.—*Structural relations of natural products* (read by Dr. R. J. S. Beer).

Prof. E. D. Hughes, F.R.S.—*Reaction mechanisms.*

September 4

The heavy chemical industry of Merseyside :

Dr. J. Ferguson.—*A general and historical survey.*

Mr. J. H. Harwood.—*The alum and aluminium sulphate industries.*

Dr. T. Kennedy.—*The development of the soap and allied industries of Merseyside.*

Mr. A. J. Carter.—*Recent developments in the petroleum industry.*

September 7

Chemotherapy and antibiotics :
Dr. W. B. Whalley.—*Introduction.*
Dr. B. A. Hems.—*The chemistry of antibiotics.*
Dr. F. L. Rose.—*Chemotherapy.*
Prof. B. G. Maegraith.—*Biological problems of chemotherapeutic research.*

September 8

Metallurgy. See entries under Section G.
Transmutation (modern alchemy) :
Dr. R. Spence, C.B.—*Transmutation and chemistry.*
Dr. K. F. Chackett.—*Transmutation by means of particle accelerators.*
Dr. R. Hurst, G.M.—*Synthetic elements produced by nuclear reactors.*

SECTION C

Geology

September 3

Prof. R. M. Shackleton.—*The geology of the Liverpool district.*
Dr. F. M. Trotter.—*Information from the recent numerous deep borings in Lancashire.*
Dr. P. E. Kent.—*Deep borings and geophysical surveys near Formby, Lancashire.*

September 4

Session A

Dr. W. H. Taylor.—*Recent developments in the structure-analysis of felspars.*
Dr. I. D. Muir.—*Some optical investigations on the Plagioclase felspars.*
Dr. E. H. T. Whitten.—*The apparent flow structure of part of the Donegal Granite, Eire.*
Dr. O. C. Farquhar.—*Mineral occurrences in the Taita Hills, Kenya.*

Session B

Prof. Ph. H. Kuenen.—*Recent deposits and the interpretation of sedimentary rocks.*
Dr. L. M. J. U. van Straaten.—*Tidal flat deposits.*
Dr. R. G. S. Hudson.—*The southern shore of Tethys : an essay in Mesozoic sedimentation.*
Dr. E. K. Walton.—*Greywacke sedimentation.*
Dr. W. W. Black.—*Carboniferous reef limestones of the North of England.*
Dr. G. Y. Craig.—*The depositional environment of a Lower Carboniferous marine shale.*

September 7

Invertebrate fossils and evolution, Presidential Address by Prof. T. Neville George.
Advances in underwater observation. Joint session. See Section D.
Mr. P. C. Sylvester-Bradley.—*Reticulation in the phylogeny of the Ammonites.*
Mr. W. S. McKerrow.—*Form and environment in Middle Jurassic Brachiopods.*

September 8

The Continental Shelf.—See under entry Section D.
Stratigraphy and Structures in North Wales :
Prof. O. T. Jones, F.R.S.—*The stratigraphy and structure of North and Central Wales (excluding Anglesey).*
Prof. R. M. Shackleton.—*Pre-Caledonian and Caledonian structures of North Wales.*
Mr. D. A. Bassett.—*Fold structures in North Montgomeryshire.*
Dr. D. W. Powell.—*The results of gravity and magnetic surveys in North Wales.*

September 9

Dr. C. T. Trechman.—*The mountain uplift problem.*
Mr. A. E. Currall.—*Preliminary report on the metamorphic rocks N.W. of Castlebar, Co. Mayo.*
Mr. D. Magraw.—*Some aspects of Lower Coal Measures stratigraphy as revealed by recent boreholes in Lancashire.*
Mr. E. G. Poole and Mr. A. J. Whiteman.—*Exploratory boreholes in the Prestwich Area of the South East Lancashire coalfield.*
Dr. R. M. C. Eagar.—*Borings in the Lower Coal Measures and Millstone Grit of Croxteth Park Inlier, near Liverpool.*
Dr. F. H. T. Rhodes.—*The Conodont fauna of the Kiesley Limestone.*

SECTION D

Zoology

September 3

The maintenance and spread of sea-shore faunas, Presidential Address by Prof. J. E. Smith.
Shellfish biology :
Mr. M. N. Mistakidis.—*Sex change in the pink shrimp* Pandalus montagui.
Mr. J. Mason.—*Growth and breeding of the scallop* Pecten maximus.
Mr. G. D. Waugh.—*Environmental factors governing oyster production in Essex.*
Mr. B. T. Hepper.—Mytilicola intestinalis, *a destructive parasite of mussels.*
Film : *How Conway mussels are fished and purified.* Commentary by Dr. H. A. Cole.
Film : *Experimental oyster culture.* Commentary by Dr. H. A. Cole.

September 4

Tropical parasitology :
Dr. P. L. LeRoux.—*Helminthology in the tropics.*
Mr. R. B. Griffiths.—*The early developmental stages of* Schistosoma mansoni *in the mammalian host.*
Dr. S. B. Kendall.—*Host specificity of snail vectors of liver flukes.*

Dr. W. E. Kershaw and Mr. W. L. Nicholas.—*Filariasis in Nigeria and the British Cameroons.*

Dr. M. Lavoipierre and Mr. W. Crewe.—*Studies of* Chrysops silacea—*a vector of the filarian* Loa loa.

Mr. R. S. Bray.—*The tissue phase of malaria parasites.*

Dr. C. F. A. Pantin, F.R.S., and Miss E. A. Robson.—*The simplest nervous system and how it works : a demonstration.*

How animals find their way about :

Dr. H. W. Lissman.—*Direction finding in fish.*

Dr. D. I. Williamson.—*Landward and seaward movements of the sandhopper* Talitrus saltator.

Dr. J. L. Cloudsley-Thompson.—*Problems of dispersal in some terrestrial Arthropods.*

Dr. J. D. Carthy.—*The rôle of vision in route-finding in insects.*

September 7

New advances in underwater observation. Jointly with Sections A, C.

Dr. H. G. Vevers.—*Photography of the sea floor.*

Mr. W. D. Chesterman.—*The taking of underwater films by frogmen.*

Mr. R. E. Craig.—*Echo-sounding in marine biology.*

Dr. H. Barnes.—*Underwater television in marine biological research.*

Dr. T. F. Gaskell.—*Seismic measurements in the Pacific.*

Dr. W. Lane-Petter.—*The use of laboratory animals in Great Britain.*

Prof. R. D. Purchon.—*The teaching of zoology in Malaya.*

Dr. C. A. Clarke and Dr. P. M. Sheppard.—*Hybridisation and pupal coloration in swallow-tail butterflies.*

September 8

The Continental Shelf. Jointly with Sections C, E.

Dr. L. H. N. Cooper.—*The Celtic Sea and Eastern North Atlantic : their hydrography in relation to marine biology and submarine geology.*

Mr. Michael Graham and Mr. A. J. Lee.—*The hydrography and natural history of the Bear Island Shelf.*

Dr. A. E. Moodie.—*Territorial problems associated with the Continental Shelf.*

Miss E. A. Robson.—*The discharge of nematocysts.*

Dr. D. J. Crisp.—*The extension of the range of* Elminius modestus *in Liverpool Bay and North Wales.*

Dr. R. Bainbridge.—*The inter-relationships of phyto- and zoo-plankton.*

Dr. E. W. Knight-Jones.—*A comparative survey of ciliary metachronism in invertebrates.*

September 9

Prof. H. R. Hewer.—*The Seals of Ramsay Island.*

SECTION E

Geography

September 3

The geography of Merseyside :

Prof. Wilfred Smith.—*Merseyside.*

Mr. R. Kay Gresswell.—*The southwest Lancashire coast.*

Prof. Wilfred Smith, Mr. G. Mercer and Mr. K. Rowe.—*The journey to work on Merseyside.*

September 4

The geographer as humanist, Presidential Address by Prof. R. H. Kinvig.

Dr. A. E. Moodie.—*Agrarian reform in East-Central Europe.*

Prof. J. H. G. Lebon.—*Baghdad : a modern Islamic city* (read by Mr. D. Hywel Davies).

Mr. E. S. Simpson.—*The Cheshire dairying district.*

Mr. J. A. Taylor.—*Agricultural land use of the lowland peats of western Britain.*

The late Mr. H. A. P. Jenson.—*The Dee Estuary : some aspects of recent physiographic changes* (read by Mr. F. J. Monkhouse).

September 7

Dr. K. A. Sinnhuber.—*Central Europe—Mitteleuropa—l'Europe Centrale : an analysis of a geographical term.*

Prof. K. C. Edwards.—*The geographical basis of Benelux.*

Prof. N. J. G. Pounds.—*The connections between Lorraine and the Ruhr.*

Miss B. Third.—*The changing landscape of Angus, Clydesdale and Lothian as revealed by 18th century estate plans.*

Miss H. C. Chew.—*The agricultural geography of Eastern Leicestershire—the revolutionary changes of our times.*

Mr. N. Stephens.—*A study of stream rejuvenation on Dartmoor.*

September 8

The Continental Shelf. Joint Session. See Section D.

Aspects of the geography of Africa :

Dr. Monica Cole.—*The citrus fruit industry in South Africa.*

Report from Tropical Africa Research Committee.

Mr. T. E. Hilton.—*The distribution and density of population in some parts of the Northern Territories Protectorate of the Gold Coast.*

Dr. H. R. Jarrett.—*The port and town of Freetown, Sierra Leone.*

Prof. R. F. Peel.—*The forests, mists and snows of Ruwenzori—an account of the expedition of* 1952.

Mr. N. Pye.—*Life and livelihood in the Arizona Desert.*

September 9

Mr. F. A. Barnes.—*Some geographical relationships of secondary fronts of instability.*

Mr. O. Hinchliffe.—*A micro-study of population drift in a Pennine valley.*

SECTION F

Economics

September 3

Mr. H. R. Parker.—*The financial aspect of Town and Country Planning legislation.*

Mr. S. B. Saul.—*The pattern of British overseas trade before the First World War.*

Mr. G. Clayton.—*The provincial Stock Exchanges.*

September 4

Open and repressed monetary inflation, Presidential Address by Prof. F. W. Paish.

Training for management. See entry under Section L.

September 7

Mr. J. C. Gilbert.—*The Austrian contribution to monetary theory.*

Mr. A. S. Mackintosh.—*Taxation of business income.*

September 8

The logic, philosophy and psychology of business decision-making under uncertainty :

Prof. W. B. Gallie.—*Uncertainty as a philosophical problem.*

Dr. D. J. O'Connor.—*Uncertainty as a philosophical problem.*

Dr. I. J. Good.—*The appropriate mathematical tools for describing and measuring uncertainty.*

Prof. G. P. Meredith.—*Methodological considerations in the study of human anticipation.*

Prof. C. F. Carter.—*Theories of expectations.*

September 9

The logic, philosophy and psychology of business decision-making under uncertainty (continued from Tuesday) :

Prof. B. R. Williams.—*The impact of uncertainty analysis upon economic theory ; illustrated from the theory of profit.*

Mr. A. D. Roy.—*The possibility of empirical testing of alternative theories of uncertainty.*

Prof. G. L. S. Shackle.—Summing up.

SECTION G

Engineering

September 3

Engineering in the next two thousand years, Presidential Address by the Rt. Hon. Lord Dudley Gordon.

Utilisation of computing machines in engineering and industry :

Prof. F. C. Williams.—*Introduction.*

Mr. R. K. Livesley.—*The utilisation of electronic computers in engineering practice.*

Mr. G. C. Alway.—*Some aspects of automatic computing in aircraft engineering.*

September 4

Session A

Dr. B. L. Goodlet.—*The outlook for economic nuclear power.*

Dr. H. Heywood.—*Solar energy : past, present and future applications.*

Session B

Mr. L. J. Murray.—*The use of electronic methods in telephone switching.*

Mr. F. C. McLean, M.B.E.—*The application of colour to television broadcasting.*

September 7

Session A

Time and motion study. Joint Session. See Section J.

Session B

Mr. A. E. Margolis.—*District heating.*

Mr. A. T. Pickles, O.B.E.—*The measurement of the efficiency of heating in buildings.*

September 8

Session A

Mr. E. W. Colbeck, Dr. J. R. Rait and Mr. J. O. Ward.—*The design of creep-resisting steels.*

Major P. L. Teed.—*Titanium : a metal o engineering importance.*

Session B

Mr. J. Wright.—*The Isodynamometer.*

Dr. J. E. Parton and Dr. W. D. Sutherland.—*Combined magnetisation of magnetic materials.*

Mr. K. L. Morphew.—*Engineering applications of calorimetry with particular reference to magnetic steels.*

Mr. R. Yorke.—*Electro-mechanical analogies.*

SECTION H

Anthropology and Archaeology

September 3

Mr. Grahame Webster.—*Roman Chester in the light of recent investigation.*

Mr. J. V. H. Eames.—*The Dark Ages on Merseyside.*

September 4

Analysis and description in social anthropology, Presidential Address by Prof. M. Fortes.

African Anthropology :

Prof. I. Schapera.—*Recent advances in anthropological research in Southern Africa.*

Dr. Audrey E. Richards.—*Some experiments in organising comparative research in East Africa.*

Anthropological research, with special reference to Africa : discussion.

September 7

The technique of surface field research in archaeology :
Mr. A. H. A. Hogg.—*The technique of surface field research.*
Mr. L. V. Grinsell.—*Field work on the Wessex Chalk.*
Mr. K. D. M. Dauncey.—*The role of the amateur research group in field research.*
Anthropological studies in industrial society :
Dr. W. H. Scott.—*Anthropology and industrial research.*
Miss J. Woodward.—*A study in the docks industry.*

September 8

The Trobriand Island to-day :
Film, introduced by Mr. H. Powell.
Mr. H. Powell.—*The Trobriand Island.*

SECTION I

Physiology

September 3

Carotenoids :
Prof. R. A. Morton, F.R.S.—*Carotenoids and related substances.*
Dr. T. W. Goodwin.—*Biosynthesis of carotenoids.*
Dr. T. Moore.—*Carotenoids in relation to sex.*
Dr. H. J. A. Dartnall.—*The light-sensitive substances of vision.*

September 4

Physiology of athletic training :
Prof. A. Hemingway.—*Physiological factors in athletic performance.*
Mr. Roger Bannister.—*The control of breathing during exercise.*
Mr. G. H. G. Dyson.—*Modern approach to distance running.*
Mr. G. T. Adamson.—*Circuit training.*
Practical aspects of training for athletics in man and other animals. Chairman : Prof. A. V. Hill, C.H., O.B.E., F.R.S.
M. J. Bateman.—*The attainment and maintenance of fitness in the racing greyhound* (Paper read by Prof. E. C. Amoroso).
Mr. J. L. Jarvis.—*Practical aspects of training thoroughbred horses for flat races* (Paper read by Mr. Wm. C. Miller).
Mr. J. Egan.—*The general fitness of Rugby League players.*
Mr. J. Lynas.—*Training professional footballers.*

September 7

Quality and quantity of protein for man and livestock, Presidential Address by Dr. D. P. Cuthbertson.
Prof. J. W. Howie.—*Diet and resistance to infection.*
Mr. A. W. Wilkinson.—*Changes in protein metabolism after injury and surgical operation.*

September 8

Cybernetics. See Section J.
Ruminant Digestion. Joint Session with Section M.
Mr. A. G. Singleton.—*The rate of passage of food through the ruminant stomach.*
Dr. R. S. Comline.—*Reflex control of the ruminant stomach.*
Dr. A. T. Phillipson.—*Absorption from the rumen of sheep.*
Mr. R. J. Garner.—*The intermediary metabolism of the ruminant.*

September 9

Natural history of certain communicable diseases :
Prof. B. G. Maegraith.—*Research approach to diseases in hot climates.*
Prof. R. M. Gordon and Dr. W. E. Kershaw.—*The spread of filariasis in the temperate and tropical zones.*
Dr. A. R. D. Adams.—*The pathogenicity of* Entamoeba histolytica.
Dr. W. H. H. Andrews.—*Physiological approach to research projects in malaria.*
Prof. T. H. Davey.—*Medical policy and the demographer.*
Prof. A. W. Downie, Dr. K. R. Dumbell, and Dr. K. McCarthy.—*Observations of infectivity of smallpox.*

SECTION J

Psychology

September 3

Dr. Hilda W. Oldham.—*Children's descriptions of pictures compared with their drawings and intelligence.*
Dr. A. L. Gregory.—*The functioning of the Ideal in adolescence and its importance as a means of education.*
Dr. D. M. Zausmer.—*An investigation of tics or habit spasms in childhood.*
Psychological problems in the recognition of excellence, Presidential Address by Prof. D. W. Harding.
Mr. D. B. Worthington.—*A study of job changing.*
Dr. J. D. Nisbet.—*A twenty-year follow-up of intelligence test scores.*

September 4

Conceptual thinking :
Prof. L. S. Hearnshaw.—*The psychological study of conceptual thinking.*
Dr. Agnes Crawford.—*Concept formation and learning.*
Dr. F. W. Land.—*Concept formation in children.*
Mr. D. B. Bromley.—*Conceptual deterioration.*
Dr. Madeline Kerr.—*A comparative study of deprivation in Jamaica and Liverpool.*

Mr. D. K. Manley.—*Organisations of colonial immigrants in Liverpool.*

September 7

Time and motion study. Joint Session with Section G.

Miss A. G. Shaw.—*The use of motion study in increasing productivity.*

Mr. Winston Rodgers.—*Techniques in motion and time study.*

Discussion opened by Mr. D. Wallis.

September 8

Cybernetics. Joint Session with Sections A and I.

Dr. E. C. Cherry.—*Organisms and mechanisms—an introductory survey.*

Dr. W. E. Hick.—*The impact of information theory on psychology.*

Dr. D. M. Mackay.—*On comparing the brain with machines.*

Abilities and social status in the Royal Air Force :

Dr. G. W. Higgin.—*The effect of reference group functions on social status ratings.*

Mrs. H. S. Anthony.—*The effect of the vocational aims of industrial apprentices upon their attitude to education and commissioning.*

Mr. A. B. Cherns.—*Abilities, social status and leadership assessment of officer candidates in the R.A.F.*

SECTION K

Botany

September 3

The evolution of the ovule in the Pteridosperms, Presidential Address by Prof. J. Walton.

Prof. S. Leclerq.—*Are the Psilophytales a starting point or a resulting point ?*

Mr. W. S. Lacey.—*Two new petrified stems from the Scottish Lower Carboniferous.*

September 4

Dr. Kathleen M. Drew Baker.—*The organisation and evolution of the carposporophyte in the Florideae.*

Miss L. M. Newton.—*Generic limits within a group of Red Algae.*

Dr. Sheila Lodge, Dr. Elsie Conway, Dr. Elsie M. Burrows and Mr. H. T. Powell.—*Algal vegetation of northern shores.*

Dr. Helen Blackler.—*Some aspects of the algal ecology of the shores of St. Andrews.*

Prof. Irene Manton.—*The ciliary apparatus in zoids of brown seaweeds, as seen with the electron microscope.*

Dr. Marie F. E. Nicolai.—*Algal cell walls.*

Mr. M. R. Droope.—*The biology of haematochrome in the alga* Haematococcus pluvialis Flotow.

Mr. D. Irvine.—*Seasonal changes in the vegetation of a rock pool.*

Miss M. P. Hare.—*An investigation of some species of* Hormidium *and* Ulothrix.

Mrs. A. Wood.—*The cytogenetics of* Altrichum.

Miss S. Bonfield.—*A suggestion for a revised classification of the Umbelliferae.*

September 7

Prof. Alan Burges.—*Decomposition of litter and the release of mineral material.*

Mr. J. D. Boatman.—*Organic decomposition in natural soils.*

Dr. R. D. Preston.—*Growth and fine structure in plant cell walls.*

Dr. J. G. Boswell.—*Some observations on oxidation systems in the higher plants.*

Dr. H. E. Street.—*Further studies on factors controlling the activity of root tip meristems.*

Dr. L. W. Poel.—*The fixation of radioactive carbon dioxide in barley roots.*

Mr. Keith Jones.—*The ecological distribution and cytology of chromosomes races in* Holcus mollis.

Mr. A. J. H. Carr.—*Homo and heterokaryons in the homothallic fungus* Sclerotinia trifoliorum Ericksson.

Dr. J. L. Crosby.—*Some observations on the biology of the primrose.*

Prof. A. S. Boughey.—*The mountain vegetation of Fernando Po, Cameroon Mountains and the Bamenda Highlands* (colour film).

September 8

The botany and afforestation of sand dunes. Joint Session with K*.

Mr. J. Macdonald.—*Tree planting on coastal sands.*

Mr. T. J. Wallace.—*The larger fungi of sand dunes.*

Prof. P. Thaarup.—*Afforestation of dunes in Denmark.*

Dr. B. Blanchard.—*Nature Reserve No. 9, Ainsdale.*

Prof. E. C. Mobbs, O.B.E.—*Life in the Himalaya.*

September 9

The effects of atmospheric pollution on vegetation :

Dr. C. R. Metcalfe.

Dr. T. R. Pearce.

Dr. A. C. Bleasdale.

SUB-SECTION K*

Forestry

September 3

The evolution of the ovule in the Pteridosperms, Presidential Address to Section K by Prof. J. Walton.

Mr. W. T. Smith.—*Private woodlands : the preparation, conversion and marketing of produce.*

September 4

The place of forestry in Britain's economy, Chairman's Address by Mr. A. P. Long, C.B.E.

Mr. Lloyd O. Owen.—*The development of operational woodland societies in the U.K.*

Mr. W. D. Evans.—*Forestry for the private owner.*

September 7

Prof. E. C. Mobbs, O.B.E.—*Forestry in Britain.*

Shelter belts of trees :

Mr. R. W. Gloyne.—*Some effects of shelter belts upon local and micro-climate.*

Mr. W. A. Cadman.—*Forestry aspects of shelter belts for hill farms.*

Prof. J. E. Nichols.—*Shelter belts in relation to hill farming.*

September 8

The botany and afforestation of sand dunes. See entry under Section K.

September 9

The effects of atmospheric pollution on vegetation. See entry under Section K.

SECTION L

Education

September 3

Backwardness in reading :

Dr. M. L. Kellmer Pringle.—*Backwardness in reading.*

Mr. J. E. Collins.—*The effects of remedial treatment.*

September 4

Greek or Chemistry or both? Presidential Address by Dr. Robert Birley, C.M.G.

Education in the East and West zones of Germany :

Dr. Gertrud Panzer.

Training for management :

Sir Charles Renold.

Prof. R. S. Edwards.

September 7

Recent development in secondary modern education :

Mr. H. C. Dent.—*Introduction* (read by Mr. G. C. E. Smith).

Miss M. Puckey.—*Integrated studies in a secondary modern school.*

Miss P. F. Messenger.—*Dramatic work in secondary modern schools.*

September 8

Interaction between school and home :

Miss R. N. Pearse.

Prof. W. O. Lester Smith, C.B.E.

September 9

Papers by research students :

Mrs. E. B. Floyer.—*A study of cerebral palsied children.*

Mr. H. Lytton.—*A genetic study of foreign language learning.*

SECTION M

Agriculture

September 3

Farm Organisation in Lancashire and Cheshire :

Mr. J. A. Duncan.—*Cheshire farming.*

Mr. J. Heyes.—*Farming in the south west Lancashire plain.*

Mr. A. H. Fitton.—*Farming problems in E. Lancs.*

Mr. A. Lazenby.—*Factors influencing the appearance and spread of rushes after ploughing and reseeding.*

September 4

Applications of animal physiology to agriculture, Presidential Address by Dr. J. Hammond, C.B.E., F.R.S.

The scientific basis of the herd book :

Dr. Alan Robertson.—*Breed structure.*

Prof. J. E. Nichols.—*Herd books, selective registration and selective breeding.*

Poultry husbandry :

Mr. M. Whalley Taylor.—*Table production in the U.S.A.*

Mr. G. Sykes.—*Applied poultry genetics in Britain and North America.*

September 7

Preventive medicine among farm livestock :

Prof. E. G. White.—*Introduction.*

Mr. J. N. Ritchie.—*The part played by the State in controlling animal disease.*

Mr. J. O. L. King.—*Husbandry and its influence on the incidence of disease in animals.*

Dr. E. L. Taylor.—*The influence of parasitic diseases on our animal production.*

September 8

Ruminant digestion. See entry under Section I.

Measurement of farm efficiency :

Mr. A. N. Duckham, C.B.E.—*Measurement of technical efficiency in farming.*

Mr. R. N. Dixey.—*Measurement of economic efficiency in farming.*

Mr. C. H. Blagburn.—*Business efficiency on the farm.*

ASSEMBLY OF CORRESPONDING SOCIETIES

September 3

Gateways of Science, Presidential Address by Dr. W. E. Swinton.

September 4

Dr. P. M. Butler.—*Trends in natural history in the north-west.*

Mr. W. F. Grimes.—*The scientific bias of archaeology.*

Mr. R. Wagstaffe.—*Natural history : the amateur and the professional.*

Mr. H. Stansfield.—*The museum botanist and the community.*

September 7

Animal health and welfare :

Dr. R. F. Gordon.—*Science in the control of poultry disease.*

Dr. C. Horton-Smith.—*The host-parasite relationship and the development of disease.*

Dr. W. R. Wooldridge.—*The scientific approach to animal welfare.*

The presentation of science :

Dr. D. A. Allan.—*The museum presentation of science.*

Mr. E. Yerbury.—*Teaching science in schools.*

Mr. P. Ritchie Calder, C.B.E.—*Presentation of science to the public.*

September 8

The protection of Nature :

Mr. F. H. W. Green.—*Town and country planning in relation to nature conservation.*

Prof. H. R. Hewer.—*The Badger* (film).

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SECTION D

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Section L

Dent, H. C. Cf. articles in *Times Ed. Suppt.* 1952.

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Section M

Lazenby, A. Cf. 'Juneus effusus: studies on germination and establishment,' to appear in *J. Ecology.*

Preventive medicine among farm livestock, *Nature*, **172**, pp. 561–2, Sept. 26, 1953; *Vet. Record* 1953, **65**, pp. 628–31.

Ritchie, J. N. To appear in *State Vet. J.*, Jan. 1954.

Robertson, Dr. A. Cf. ' A. Robertson and A. A. Asker, The genetic history and breed structure of British Friesian Cattle,' *Emp. J. Expt. Agric.*, **19,** 113–30 (1951) ; A. Robertson, ' A numerical description of Breed Structure,' *J. Agric. Sci.*, in press ; A. Robertson and J. M. Rendel, ' The performance of Heifers got by artificial insemination,' *J. Agric. Sci.*, in press.

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Green, F. H. W. Cf. ' The Nature Conservancy in Scotland,' *Scot. Geog. Mag.*, July 1952.

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REPORT OF COUNCIL TO THE GENERAL COMMITTEE, 1952–53

(Received and adopted by the General Committee on September 2, 1953)

Obituary

1. Since the Council's last report the Association has mourned the passing of Sir Richard Gregory, Bt., F.R.S. (President 1940 to 1946), and has suffered further loss by the death of the following office-bearers and supporters :

Dr. Wm. Brown
Dr. W. T. Calman, C.B.E., F.R.S.
Prof. G. D. Hale Carpenter
Sir William Dampier
Prof. C. B. Fawcett
H. M. Hallsworth
Sir Frederick Keeble, C.B.E., F.R.S.
Prof. R. A. Laurie
Prof. F. C. Lea, O.B.E.
Prof. C. H. Lees, F.R.S.
Mr. J. H. Leycester
Prof. J. W. McBain, F.R.S.
Prof. J. H. Orton, F.R.S.
Dr. S. J. F. Philpott
Prof. H. E. Roaf
Lord Robinson
Dr. G. F. Herbert Smith
Prof. F. E. Weiss, F.R.S.

2. The Association was represented at the following memorial services : for Sir Richard Gregory, by Prof. A. V. Hill (then President) and by Sir Henry Dale, Sir Henry Tizard, Sir Harold Hartley and many other members of the Council ; for Lord Robinson by Prof. Champion ; for Dr. Philpott by Prof. Vernon ; and for Dr. Herbert Smith by Dr. J. Ramsbottom.

Relations with other Institutions

3. By the appointment of official representatives and in other ways the Association has maintained cordial relations with scientific institutions at home. Changes in representation during the year included the appointment of Dr. George Taylor as the Association's representative on the Wild Plant Conservation Board of the Council for the Preservation of Rural England, and the appointment of Dr. Maurice Hill as a member of the National Committee for Geodesy and Geophysics. The Council accepted as a new obligation an invitation from the Secondary Schools Examinations Council to recommend suitable people when appointments were being made to membership of subject panels.

4. As regards international relations the Association's overseas contacts have been well maintained. Sir Edward Appleton, as President accepted office as a Vice-President of the Quinquennial Congress of Commonwealth Universities and as a Patron of the Annual Congress of the International Scientific Films Association. Under a generous agreement with the British Council the Association was represented at the annual meeting of the Indian Science Congress Association by Sir Richard Southwell and at the meeting of the Pakistan Association by Sir Harold Hartley and Dr. George Taylor. Under the same agreement representatives from India and Pakistan will attend the Liverpool meeting. Prof. Winifred Cullis attended the meeting of the French Association in Luxembourg and Prof. A. V. Hill has accepted an invitation to attend the next meeting of the American Association.

5. Through correspondence, contacts with other Associations for the Advancement of Science have been maintained, as far as possible, but efforts to enlarge those contacts through an extension of representation at annual meetings have not, so far, been fruitful. Hopes of obtaining support from Unesco have faded during prolonged discussion on procedure.

6. In accordance with a policy decision taken some time ago the Council declined an invitation to arrange joint sessions with the International Commission on *Oceanography* during the Liverpool meeting and suggested that the Commission's Congress be held at a time which would allow overseas members of the Commission to be present at the Association's meeting.

This has been happily arranged and several distinguished foreign oceanographers will be received as guests during the meeting.

Coronation

7. The Association was represented by Sir John Russell at the coronation of Her Majesty, Queen Elizabeth in Westminster Abbey on June 2, 1953.

Belfast Meeting

8. The final registered attendance at the Belfast meeting was 4,643 subscribing members not counting several thousand school children who attended special afternoon lectures. Over 1,000 secondary school children became junior members for the meeting. In retrospect, the Council have considered the interest of young people to have been one of the most significant features of a wholly successful meeting in Belfast. Since, however, the young people who became members did not particularly wish to have lectures to which only children were admitted, the Council have encouraged the Sections to include non-specialist items in their programmes and to announce such items as being suitable for non-specialists of all ages.

Liverpool Meeting

9. The Council gratefully acknowledge willing and generous assistance given by local officers and Committees in making preparation for the sixth meeting in Liverpool. The Council also acknowledge with appreciation the President's decision to deliver a Junior Presidential Address.

Future Meetings

10. *Oxford*, 1954. The General Committee have already accepted an invitation to hold the next meeting in Oxford during the period September 1–8 inclusive and the Council have appointed the following local officers : Treasurer : The City Treasurer ; Secretaries : The Town Clerk and the Registrar of the University. The Local Executive Committee have appointed the Vice-Chancellor of the University and the Mayor of Oxford as joint Chairmen and Dr. D. B. Harden as Vice-Chairman. The following have accepted the Council's invitations to serve as Presidents :

Section

A Sir John Cockcroft, C.B.E., F.R.S.
B Sir John Lennard-Jones, K.B.E., F.R.S.
C Dr. C. J. Stubblefield, F.R.S.
D Dr. G. R. de Beer, F.R.S.
E Prof. J. A. Steers
F Prof. E. A. G. Robinson
G Prof. Willis Jackson, F.R.S.
H Sir Mortimer Wheeler, C.I.E.
I Prof. A. D. Macdonald
J Prof. L. S. Hearnshaw
K Prof. W. H. Pearsall, F.R.S.
L Mr. Ronald Gould
M Dr. R. E. Slade

Assembly of Corresponding Societies : Dr. C. B. Williams.

11. *Bristol*, 1955. The Council have received a joint invitation from the City and University of Bristol to hold the 1955 meeting there. The invitation has been provisionally accepted and the Council unanimously recommend that acceptance be confirmed.

12. *Dublin*, 1957. An invitation to meet in Dublin in 1957 has been received from the Lord Mayor of the City and from the heads of Trinity College and University College. This invitation has been provisionally accepted and the Council unanimously recommend that acceptance be confirmed.

Officers and Council

13. *President*, 1954. The Council unanimously nominate Dr. E. D. Adrian, O.M., P.R.S., for appointment.

14. *General Officers*, 1953–54. The Council nominate for re-appointment as General Officers for the year 1953–54 :

General Treasurer : Mr. M. G. Bennett. General Secretaries : Sir Richard Southwell, F.R.S., and Dr. George Taylor.

15. *Ordinary Members of Council*, 1953–54. The members retiring under Statute III, 3, are : Wing-Commander T. R. Cave-Browne-Cave, C.B.E., Prof. Winifred Cullis, C.B.E., Dr. H. Hamshaw Thomas, M.B.E., F.R.S., Prof. A. W. Wolters and Prof. F. Balfour-Browne. Under the powers given to them by Statute the Council nominate for appointment : Prof. H. R. Hewer, Prof. A. D. Macdonald and

Prof. P. E. Vernon, leaving two vacancies in the ordinary membership to be filled by the General Committee without nomination by the Council. The following is the full list of nominations recommended for approval by the General Committee. If this list is approved each Section will have the required minimum of two representatives and the two remaining vacancies can be filled without regard to the representation of particular Sections.

R. J. Bartlett
Prof. L. F. Bates, F.R.S.
M. C. Burkitt
Prof. H. G. Champion, C.I.E.
Sir Alfred Egerton, F.R.S.
Prof. H. P. Gilding
Dr. Ezer Griffiths, O.B.E., F.R.S.
Dr. D. B. Harden
Prof. H. R. Hewer
Prof. K. S. Isles
A. Gray Jones
Sir Harold Spencer Jones, F.R.S.
Prof. H. D. Kay, C.B.E., F.R.S.
Sir Ben Lockspeiser, K.C.B., F.R.S.
Prof. A. D. Macdonald
J. Wickham Murray, O.B.E.
Prof. F. W. Paish
Prof. W. J. Pugh, O.B.E., F.R.S.
Dr. J. Ramsbottom, O.B.E.
Lord Rennell of Rodd, K.B.E., C.B.
Prof. L. Dudley Stamp, C.B.E.
Dr. W. E. Swinton
Dr. C. Tierney
Prof. P. E. Vernon
Prof. W. Wardlaw, C.B.E.
W. H. Wilcockson
Dr. H. E. Wimperis, C.B., C.B.E.
Dr. N. C. Wright.

(The General Committee appointed Prof. Kathleen Lonsdale, F.R.S., and Prof. Willis Jackson, F.R.S., to fill the two remaining vacancies.)

16. *Honorary Auditors*, 1953–54. The Council recommend the reappointment of Sir John Simonsen, F.R.S., and Dr. H. J. T. Ellingham.

General Committee

17. The following have been admitted to membership of the General Committee on the recommendation of Section Committees :

J. S. Colman
Dr. Isabella Gordon
Miss M. V. Griffith
A. C. Hartley, C.B.E.
H. P. Hewitt
A. G. G. Hill
Sir Patrick Laird, K.B.E., C.B.
Dr. G. H. Mitchell
Prof. H. O'Neill
Dr. R. C. Pink
Sir Wm. Slater
Col. J. A. Symon
Prof. Wilfred Smith
G. Williams

Finance

18. The General Treasurer's Accounts will be presented to the General Committee in full detail. The General Income and Expenditure Account for the financial year ending March 31, 1953, shows a deficit which is larger than usual but no larger than was foreseen when the General Committee was invited by the Council to raise membership subscriptions. In the next financial year the Association will have the benefit of an increased yield from subscriptions and from deeds of covenant but the Council are still of the opinion that further capital endowment will be required to ensure continued financial stability.

Down House

19. During the Belfast meeting in 1952, the General Committee authorised the Council to take such action as would determine the future of Down House within the next twelve months and, if possible, to bring to a conclusion discussion with responsible bodies who might be interested in maintaining the Darwin Memorial. The Council have made satisfactory progress during the year and hope to be able to report to the General Committee, at Liverpool, a wholly acceptable solution of this problem.

(The General Committee received and approved a report that the Royal College of Surgeons had agreed to accept responsibility for the Darwin Memorial as from September 2, 1953.)

Research

20. Following the Belfast meeting, the Council appointed ten research committees on the recommendation of Sections and made grants to four of them. The Committees with their terms of reference and membership were published in *The Advancement of Science*, No. 37, page 80.

21. *Science and Industry.* The Council also appointed, on the recommendation of Section F (Economics), a Committee, under the Chairmanship of Prof. C. F. Carter and with a membership representative of interested Sections, to study the problem of speeding up the application of scientific research in industry. This Committee has taken preliminary evidence and has prepared a programme of work calling for funds beyond the means of the Association but the Council have agreed to act as trustee for funds raised from other sources and have considered the possibility of widening the sponsorship of the Committee's work. A further report will be submitted to the General Committee in due course.

22. *Biology in Schools.* The Council have authorised the publication and wide distribution of off-prints, of a valuable report on the teaching of biology in schools prepared by a research committee which has completed its work.

Memorial Lectures

23. The Norman Lockyer Lecture was delivered in the Philharmonic Hall, Liverpool, on January 19, 1953, when the Astronomer Royal, Sir Harold Spencer Jones, F.R.S., addressed a large public audience on ' The Bounds of Space.'

24. The delivery of the Alexander Pedler Lecture was chosen by the Council as an appropriate opportunity to pay tribute to the late Sir Richard Gregory, Bt., F.R.S., for his long and distinguished service to science with special reference to his work for *Nature*, for the British Science Guild and for the British Association. The lecture, on ' The Life and Times of Sir Richard Gregory,' was delivered by Sir Harold Hartley, K.C.V.O., F.R.S., in the Royal Institution, London, on May 28, 1953, and the text will be published in *The Advancement of Science*, No. 39 (December 1953).

Publications

25. *The Advancement of Science* has been published regularly and has maintained a quarterly circulation of about 3,250 copies.

26. The Scientific Survey, *Belfast and its Region*, published in the name of the Association by the Local Executive Committee for the Belfast meeting, maintained the high post-war standard of this series and the Council gratefully acknowledge this generous gift to members of the Association.

Resolutions

27. *Bilston Glen.* At the Birmingham meeting (1950) and the Edinburgh meeting (1951), the Sections of Geology, Zoology, Geography and Botany with the support of the Conference of Delegates of Corresponding Societies raised anxious protest against proposals to fill in the glen of the Bilston Burn with debris from a new coalmine at Loanhead, Midlothian, with consequent obliteration of a valuable inland section of fossil-bearing carboniferous rocks. The Council took appropriate action to raise the matter with the public bodies concerned. At the Belfast meeting (1952) the same Sections sent a deputation to the President and General Officers with the result that an action Committee was appointed to give publicity to continued concern over this matter and to advise the Council. It has not proved possible to prevent the beginning of dumping but the Council are grateful to Col. Walter Elliot for ventilating the matter forcibly in the House of Commons in an adjournment debate. The Secretary of State for Scotland announced during the debate that enquiries were being made into the possibility of transferring dumping to an adjoining site at the close of ten to fifteen years from 1952. The Council have agreed to keep in close touch with all concerned (including Nature Conservancy and the Parliamentary and Scientific Committee) and to press for action, if necessary.

Prizes

28. *South Africa Medal.* The Council have approved the award of the South Africa Medal to Dr. P. V. Tobias for his paper on ' The Sex Chromosomes of the Gerbil, Tatera Brantisii Drace.'

29. *Exhibitioners' Essay.* The prize offered by the Council for the best essay by an Exhibitioner on the Belfast meeting was awarded to Mr. D. C. Arnold.

30. *Endeavour Essay Prizes*, 1953. In the fourth of the Endeavour Essay Com-

petitions for prizes offered by the publishers of *Endeavour* in connection with annual meetings of the Association the successful competitors were: Mr. J. R. Shakeshaft (first), Mr. I. H. Gould (second), Mr. Abdul Zafar (third). Special prizes for competitors under eighteen years of age were awarded to Gregory Stewart, Mavis Green and Peter Newbold.

Statutes and Regulations

31. The Council have received representations that the Statutes and Regulations should be revised in the light of post-war experience but have no recommendations to submit to the General Committee at this stage. The representations will receive further consideration after the Liverpool meeting.

RESEARCH COMMITTEES, 1953-54

Grants of money, if any, from the Association for expenses connected with researches are indicated in heavy type.

SECTION A.—MATHEMATICS AND PHYSICS.

Seismological investigations.—Dr. R. Stoneley, F.R.S. (*Chairman*), Mr. E. Tillotson (*Secretary*), Mr. E. F. Baxter, Miss E. F. Bellamy, Prof. P. G. H. Boswell, O.B.E., F.R.S., Mr. B. C. Browne, Sir Edward Bullard, F.R.S., Dr. K. F. Chackett, Dr. G. E. R. Deacon, F.R.S., Dr. A. T. J. Dollar, Dr. A. E. M. Geddes, O.B.E., Prof. G. R. Goldsbrough, C.B.E., F.R.S., Dr. M. N. Hill, Mr. J. S. Hughes, Sir Harold Jeffreys, F.R.S., Mr. E. N. Lawrence, Dr. A. W. Lee, Dr. A. O. Rankine, O.B.E., F.R.S., Rev. C. Rey, S. J., Dr. G. D. Robinson, Mr. H. V. Shaw, Sir Frank Smith, G.C.B., G.B.E., F.R.S.

SECTION C.—GEOLOGY.

To excavate critical geological sections in Great Britain.—Mr. W. H. Wilcockson (*Chairman*), Dr. G. Y. Craig (*Secretary*), Sir Edward Bailey, M.C., F.R.S., Mr. J. L. Begg, Mr. W. S. Bisat, F.R.S., Prof. P. H. G. Boswell, O.B.E., F.R.S., Prof. A. H. Cox, Dr. E. E. L. Dixon, Prof. W. G. Fearnsides, F.R.S., Prof. H. L. Hawkins, F.R.S., Prof. G. Hickling, F.R.S., Dr. R. G. S. Hudson, Prof. V. C. Illing, F.R.S., Prof. O. T. Jones, F.R.S., Dr. Murray Macgregor, Mr. T. G. Miller, Prof. L. R. Moore, Dr. F. J. North, Prof. F. W. Shotton, M.B.E., Dr. W. E. Swinton, Dr. F. S. Wallis, Prof. D. M. S. Watson, F.R.S., Prof. T. S. Westoll, Prof. W. F. Whittard, Prof. S. W. Wooldridge. **£30.**

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SECTION D.—ZOOLOGY.

To carry out dredging and similar investigations in Lough Ine and neighbourhood.—Prof. R. A. R. Gresson (*Chairman*), Prof. L. P. W. Renouf (*Secretary*), Prof. J. Bayley Butler, Dr. H. O. Bull.

SECTIONS D, K.—ZOOLOGY, BOTANY.

Co-ordinating commitee for Cytology and Genetics.—Prof. Sir Ronald Fisher, F.R.S. (*Chairman*), Mr. Watkin Williams (*Secretary*), Dr. J. L. Crosby, Prof. C. D. Darlington, F.R.S., Dr. E. B. Ford, F.R.S., Dr. J. Hammond, C.B.E., F.R.S., Prof. S. C. Harland, F.R.S., Dr. J. S. Huxley, F.R.S., Prof. T. J. Jenkin, C.B.E., Prof. K. Mather, F.R.S., Prof. L. S. Penrose, F.R.S., Dr. G. Pontecorvo, Dr. R. R. Race, F.R.S., Prof. P. T. Thomas, Dr. W. B. Turrill, Prof. C. H. Waddington, F.R.S.

SECTION E.—GEOGRAPHY.

To collect and record information on demography and seasonal activities in relation to environment in Inter-Tropical Africa.—Prof. A. G. Ogilvie, O.B.E. (*Chairman*), Mr. R. W. Steel (*Secretary*), Prof. S. J. K. Baker, Dr. R. J. Harrison Church, Prof. F. Debenham, O.B.E., Prof. B. J. Garnier, Dr. E. J. Howell, Mr. D. B. Mather, Prof. L. D. Stamp, C.B.E., Prof. W. J. Varley, Prof. J. H. Wellington, Prof. J. H. G. Lebon, Prof. R. Miller. **£5.**

To prepare a glossary of geographical terms with agreed definitions in English, including reference to origin and to current use and misuse.—Prof. L. Dudley Stamp, C.B.E. (*Chairman*), Mr. G. R. Crone (*Secretary*), Prof. H. C. Darby, Prof. E. G. East, Mr. E. O. Giffard, M.B.E., Mr. A. F. Martin, Prof. A. A. Miller, Dr. C. J. Robertson, Mr. C. T. Smith, Dr. G. T. Warwick, Prof. S. W. Wooldridge, Mr. R. A. Skelton. **£5.**

SECTION H.—ANTHROPOLOGY.

To co-operate with a committee of the Royal Anthropological Institute—in the exploration of caves in the Derbyshire district.—Mr. M. C. Burkitt (*Chairman*), Mr. A. Leslie Armstrong (*Secretary*), Dr. Arthur Court, Prof. H. J. Fleure, F.R.S., Mr. W. H. Hanbury, Dr. J. Wilfred Jackson, Mr. R. U. Sayce.

To co-operate with the Torquay Natural History Society in investigating Kents Cavern.—Mr. M. C. Burkitt (*Chairman*), Prof. F. E. Zeuner (*Secretary*), Mr. A. L. Armstrong, Prof. V. G. Childe, Mr. A. G. Madan, Dr. K. P. Oakley, Mr. E. Pyddoke.

To consider the possibility of archaeological work on vacant sites in the city of Leicester.—Prof. I. A. Richmond (*Chairman*), Dr. D. B. Harden (*Secretary*), Mr. Philip Corder, Mr. A. Leslie Armstrong, Mr. D. T-D. Clarke, Mr. K. D. M. Dauncey, Mr. R. G. Goodchild.

To assist in the work of compiling an *Inventoria Archaeologica* as part of an international enterprise sponsored by the International Congress of Prehistoric Sciences.—Prof. E. O. James, (*Chairman*), Dr. D. B. Harden (*Secretary*), Prof. C. F. C. Hawkes. **£10.**

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

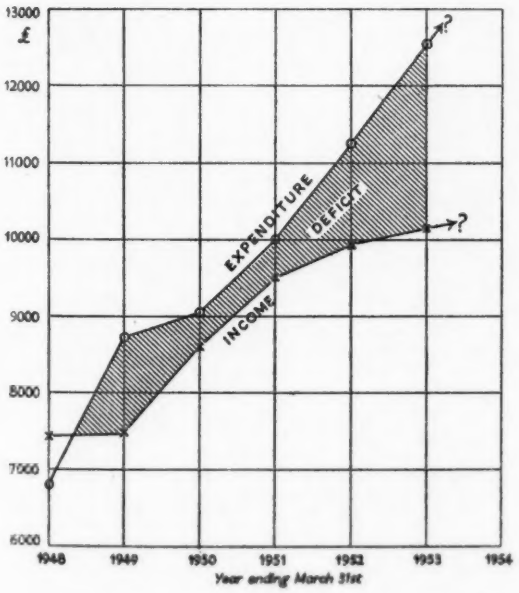
GENERAL TREASURER'S STATEMENT AND ACCOUNT, 1952–53

At the end of a financial year, which included an annual meeting with the highest attendance outside London, it is, at first sight, disappointing to report a deficit of £2,415 on the year's working; but size does not ensure solvency, however desirable it may be for the advancement of Science. The result was not unexpected. To get the figure in perspective it should be realised that the corresponding figure for last year would have been £1,329 had the Association not received the surplus of the Edinburgh Local Fund. Practically everything on the expenditure side has risen, the largest items being for travelling, office decorations (the first since 1924), printing and salaries. The increase in income from subscriptions, donations, and income tax recovered on covenants has not been sufficient to offset the increase in expenditure.

The broad trend of our finances is shown in the graph below. We are fortunate in that the drain on our accumulated capital has been stemmed to some extent by donations. For these we are very grateful. Thus we are still left with practically £41,000 in the Accumulated Fund (at cost).

However, it will be seen that if our budget is to balance, the increased subscription rates and covenants will have to bring in about £3,500 more. Although this is possible, if the covenant scheme receives the support it should have and if membership numbers are maintained, it is also obvious that to meet the further increases in expenditure which can be expected after 1954, the Association will have to seek further capital endowment, as its Finance Committee has advised.

The state of the Special Funds calls for no particular comment except that the capital of the Down House Fund has been further reduced to meet running expenses of the Darwin Memorial. As is explained in the Report of the Council to the General Committee, it is hoped that this problem is now resolved.



Certain adjustments have been made in the Association's investments which have increased income to some slight extent.

Council have been pleased to confirm the appointment of Mr. John Robertson as Assistant Secretary, and recognise with gratitude the services of all the members of the Association's staff.

M. G. Bennett,
General Treasurer.

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The collection, preservation, and systematic registration of photographs of geological interest.—Prof. H. L. Hawkins, F.R.S. (*Chairman*), Dr. W. S. Pitcher (*Secretary*), Mr. H. Ashley, Mr. G. M. Davies, Mr. W. G. Hardie, Dr. N. Holgate, Mr. G. S. Johnstone, Dr. A. G. MacGregor, Dr. F. J. North, Mr. J. Ranson, Mr. G. S. Sweeting, Prof. W. F. Whittard.

To consider and report on questions affecting the teaching of geology in schools.—Prof. T. N. George (*Chairman*), Dr. Mabel E. Tomlinson (*Secretary*), Miss M. A. Arber, Mr. A. Bray, Prof. A. H. Cox, Miss Gaynor Evans, Prof. W. G. Fearnsides, F.R.S., Prof. G. Hickling, F.R.S., Prof. D. E. Innes, Dr. J. F. Kirkaldy, Prof. D. Leitch, Prof. L. R. Moore, Prof. W. J. Pugh, O.B.E., F.R.S., Dr. K. S. Sandford, Dr. S. H. Straw, Dr. Dighton Thomas, Dr. A. K. Wells, Prof. A. Wood.

SECTION D.—ZOOLOGY.

To carry out dredging and similar investigations in Lough Ine and neighbourhood.—Prof. R. A. R. Gresson (*Chairman*), Prof. L. P. W. Renouf (*Secretary*), Prof. J. Bayley Butler, Dr. H. O. Bull.

SECTIONS D, K.—ZOOLOGY, BOTANY.

Co-ordinating commitee for Cytology and Genetics.—Prof. Sir Ronald Fisher, F.R.S. (*Chairman*), Mr. Watkin Williams (*Secretary*), Dr. J. L. Crosby, Prof. C. D. Darlington, F.R.S., Dr. E. B. Ford, F.R.S., Dr. J. Hammond, C.B.E., F.R.S., Prof. S. C. Harland, F.R.S., Dr. J. S. Huxley, F.R.S., Prof. T. J. Jenkin, C.B.E., Prof. K. Mather, F.R.S., Prof. L. S. Penrose, F.R.S., Dr. G. Pontecorvo, Dr. R. R. Race, F.R.S., Prof. P. T. Thomas, Dr. W. B. Turrill, Prof. C. H. Waddington, F.R.S.

SECTION E.—GEOGRAPHY.

To collect and record information on demography and seasonal activities in relation to environment in Inter-Tropical Africa.—Prof. A. G. Ogilvie, O.B.E. (*Chairman*), Mr. R. W. Steel (*Secretary*), Prof. S. J. K. Baker, Dr. R. J. Harrison Church, Prof. F. Debenham, O.B.E., Prof. B. J. Garnier, Dr. E. J. Howell, Mr. D. B. Mather, Prof. L. D. Stamp, C.B.E., Prof. W. J. Varley, Prof. J. H. Wellington, Prof. J. H. G. Lebon, Prof. R. Miller. **£5.**

To prepare a glossary of geographical terms with agreed definitions in English, including reference to origin and to current use and misuse.—Prof. L. Dudley Stamp, C.B.E. (*Chairman*), Mr. G. R. Crone (*Secretary*), Prof. H. C. Darby, Prof. E. G. East, Mr. E. O. Giffard, M.B.E., Mr. A. F. Martin, Prof. A. A. Miller, Dr. C. J. Robertson, Mr. C. T. Smith, Dr. G. T. Warwick, Prof. S. W. Wooldridge, Mr. R. A. Skelton. **£5.**

SECTION H.—ANTHROPOLOGY.

To co-operate with a committee of the Royal Anthropological Institute—in the exploration of caves in the Derbyshire district.—Mr. M. C. Burkitt (*Chairman*), Mr. A. Leslie Armstrong (*Secretary*), Dr. Arthur Court, Prof. H. J. Fleure, F.R.S., Mr. W. H. Hanbury, Dr. J. Wilfred Jackson, Mr. R. U. Sayce.

To co-operate with the Torquay Natural History Society in investigating Kents Cavern.—Mr. M. C. Burkitt (*Chairman*), Prof. F. E. Zeuner (*Secretary*), Mr. A. L. Armstrong, Prof. V. G. Childe, Mr. A. G. Madan, Dr. K. P. Oakley, Mr. E. Pyddoke.

To consider the possibility of archaeological work on vacant sites in the city of Leicester.—Prof. I. A. Richmond (*Chairman*), Dr. D. B. Harden (*Secretary*), Mr. Philip Corder, Mr. A. Leslie Armstrong, Mr. D. T-D. Clarke, Mr. K. D. M. Dauncey, Mr. R. G. Goodchild.

To assist in the work of compiling an *Inventoria Archaeologica* as part of an international enterprise sponsored by the International Congress of Prehistoric Sciences.—Prof. E. O. James, (*Chairman*), Dr. D. B. Harden (*Secretary*), Prof. C. F. C. Hawkes. **£10.**

Balance Sheet, 31st March, 1953

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES

	£ s. d.	£ s. d.
General Purposes:—		
Sundry Creditors	1,764 16 7	
Amounts received in advance for publications	160 13 4	
Membership and Associateship subscriptions in advance	212 5 3	
Amount temporarily held on behalf of Seismological Investigations Committee (Dr. J. E. Crombie's bequest)	1,000 0 0	3,137 15 2
Accumulated Fund		
As per last Account	44,050 11 1	
Less Loss on stock sold for re-investment	684 14 8	
Excess of Expenditure over Income for the year on General Account	2,415 13 8	
	3,100 8 4	40,950 2 9
Life Membership Fund		
As per last Account	6,831 1 4	
Add Subscriptions received during year	630 0 0	
Add, Life Members' donations	630 0 0	8,091 1 4
[53,803 13 4]		52,178 19 3
Development Fund		
As per last Account	6,350 4 1	
Add Excess of Income over Expenditure for the year	179 2 11	
[6,350 4 1]		6,529 7 0
Special Purposes:—		
Caird Fund		
Capital	9,928 17 9	
Less Loss on stock sold for re-investment	417 7 10	
	9,511 9 11	
Income and Expenditure Account balance as per last Account	602 14 1	
Less Excess of Expenditure over Income for the year	52 3 6	
	550 10 7	
Sundry creditors	17 19 7	
[10,531 11 10]		10,080 0 1
Toronto University Presentation Fund		
Capital	178 11 4	
Income and Expenditure Account balance as per last Account	5 0 9	
Less Excess of Expenditure over Income for the year	2 9	
	4 18 0	
[183 12 1]		183 9 4
Bernard Hobson Fund (1933)		
Capital	1,093 2 6	
Income and Expenditure Account balance as per last Account	430 13 7	
Less Excess of Expenditure over Income for the year	117 10 11	
	313 2 8	
[1,523 16 1]		1,406 5 2
Leicester and Leicestershire Fund, 1933		
Capital	1,000 0 0	
Income and Expenditure Account balance as per last Account	153 7 11	
Add Excess of Income over Expenditure for the year	15 9	
	154 3 8	
[1,153 7 11]		1,154 3 8
Radford Mather Lecture Fund (1936)		
Capital	250 0 0	
Income and Expenditure Account balance as per last Account	35 19 4	
Add Excess of Income over Expenditure for the year	6 14 5	
	42 13 9	
[285 19 4]		292 13 9
[73,832 4 8] Carried forward		71,824 18 3

ASSETS

	£ s. d.	£ s. d.
General Purposes:—		
Investments as scheduled with Income and Expenditure Account, No. 1	51,378 14 0	
Sundry debtors	348 0 6	
Addressing machine, as per last Account	121 10 0	
Less Amount charged to Income and Expenditure Account for the year	40 10 0	
	81 0 0	
Stock of Badges	287 13 10	
Cash at bank	83 10 11	
[53,803 13 4]		52,178 19 3
Development Fund		
Investments (see Income and Expenditure Account No. 2)	6,152 6 0	
Cash at bank	377 1 0	
[6,350 4 1]		6,529 7 0
Special Purposes:—		
Caird Fund		
Investments (see Income and Expenditure Account, No. 3)	9,911 9 11	
Cash at bank	168 10 2	
[10,531 11 10]		10,080 0 1
Toronto University Presentation Fund		
Investment (see Income and Expenditure Account, No. 4)	178 11 4	
Cash at bank	4 18 0	
[183 12 1]		183 9 4
Bernard Hobson Fund (1933)		
Investments (see Income and Expenditure Account, No. 5)	1,243 2 6	
Cash at bank	163 2 8	
[1,523 16 1]		1,406 5 2
Leicester and Leicestershire Fund, 1933		
Investments (see Income and Expenditure Account, No. 6)	1,000 0 0	
Cash at bank	154 3 8	
[1,153 7 11]		1,154 3 8
Radford Mather Lecture Fund (1936)		
Investments (see Income and Expenditure Account, No. 7)	250 0 0	
Cash at bank	42 13 9	
[285 19 4]		292 13 9
[73,832 4 8] Carried forward		71,824 18 3

Balance Sheet, 31st March, 1953 (*continued*)

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES (*continued*)

		£ s. d.	£ s. d.
[*73,832 4 8*]	Brought forward		71,824 18 3
	Arthur Haydock Bequest (1945)		
	Capital	2,215 12 0	
	Income and Expenditure Account balance as per last Account	419 12 0	
	Add Excess of Income over Expenditure for the year	73 14 5	
		493 6 5	
[*2,635 4 0*]			2,708 18 5
	Corcoran Gift (1946)		
	Capital	100 0 0	
	Income and Expenditure Account balance as per last Account	6 10 2	
	Add Excess of Income over Expenditure for the year	3 5 1	
		9 15 3	
[*106 10 2*]			109 15 3
	Down House		
	Endowment Fund as per last Account	16,843 19 10	
	Less Net loss on sale of stock	177 16 3	
	Excess of Expenditure over Income for the year	2,108 19 10	
		2,286 16 1	
		14,557 3 9	
	Library Fund	3 11 4	
	Sundry Creditors	927 19 11	
[*17,757 13 5*]			15,488 15 0
[*94,331 12 3*]			£90,132 6 11

ASSETS (*continued*)

		£ s. d.	£ s. d.
[*73,832 4 8*]	Brought forward		71,824 18 3
	Arthur Haydock Bequest (1945)		
	Investments (see Income and Expenditure Account, No. 8)	2,465 12 0	
	Cash at bank	243 6 5	
[*2,635 4 0*]			2,708 18 5
	Corcoran Gift (1946)		
	Investment (see Income and Expenditure Account, No. 9)	100 0 0	
	Cash at Bank	9 15 3	
[*106 10 2*]			109 15 3
	Down House		
	Investments (see Income and Expenditure Account, No. 10)	14,020 7 9	
	Sundry Debtors	9 19 1	
	Cash at bank and in hand	1,458 8 2	
[*17,757 13 5*]			15,488 15 0
[*94,331 12 3*]			£90,132 6 11

We have examined the foregoing Account with the Books and Vouchers and certify the same to be correct. We have also verified the Balance at the Bankers and the Investments, and have inspected the Deeds of Down House.

Approved:
J. L. SIMONSEN
H. J. T. ELLINGHAM } *Auditors.*

W. B. KEEN & CO., *Chartered Accountants*,
Finsbury Circus House, E.C. 2.

17th June, 1953.

INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31st MARCH, 1953

No. 1. General Income and Expenditure

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£7,011 8s. 2d. Consolidated 2½ per cent. Stock (Inscribed)	5,401 3 0
	£1,252 16s. 2d. Consolidated 2½ per cent. Stock (Registered)	1,000 0 0
	£1,999 0s. 4d. British Gas 3 per cent. Stock, 1990/95	1,520 14 10
	£18,400 0s. 0d. 3 per cent. Savings Bonds, 1965/75	19,098 11 9
	£52 12s. 7d. 3½ per cent. War Stock (Post Office issue)	54 5 2
	£7,704 6s. 2d. 3½ per cent. War Stock, 1952 or after	7,840 0 9
	£6,768 15s. 7d. 3½ per cent. Conversion Stock, 1961 or after	5,726 8 11
	£4,184 18s. 2d. 2½ per cent. Treasury Stock, 1975 or after	4,184 18 2
	£1,400 0s. 0d. 4 per cent. Funding Loan Stock, 1960/90	1,622 0 0
	£981 10s. 0d. 4 per cent. Commonwealth of Australia Stock 1955/70	1,000 0 0
	£4,897 18s. 11d. 3 per cent. British Transport Stock, 1978/88	3,824 11 2
	£100 0s. 0d. 3 per cent. Defence Bonds	101 0 3
	Post-war Credit, J. R. Solly, deceased	5 0 0
[*52,063 8 8*]	[*Value of stocks at 31/3/52, £41,309 13s. 0d.*] (Value at 31/3/53, £42,746 13s. 5d.)	£51,378 14 0

EXPENDITURE

	£ s. d.	£ s. d.
To Heat, Lighting and Power		92 6 8
„ Stationery		614 10 10
„ Part cost of addressing machine		40 10 0
„ Rent		1 0 0
„ Postages		425 17 3
„ Telephone		34 12 3
„ Insurances		11 15 10
„ Travelling expenses		734 11 11
„ Audit for 1951-52		94 10 0
„ Exhibitioners:	230 8 11	
Less Contribution by Liverpool University	50 0 0	
		180 8 11
„ Office decoration, etc.		215 8 10
„ Subscription to Parliamentary and Scientific Committee		15 15 0
„ Hire of meeting rooms, equipment, etc.		15 10 0
„ Lift Inspection and Repairs		16 7 6
„ Carriage of goods		45 9 2
„ Reference books, press cuttings, etc.		30 2 0
„ General expenses		46 14 1
„ Advertising		64 11 0
„ Panels of armorial bearings		13 18 6
„ Salaries, wages, pensions and National Insurance		4,718 6 11
„ Printing, etc.—		
"The Advancement of Science"	2,828 18 5	
Preliminary Programme, 1952	598 4 10	
Programme, 1952	739 9 0	
Miscellaneous	502 12 10	
		4,669 5 1
„ Norman Lockyer Lecture, 1953: Fee		10 10 0
„ Hospitality		186 0 0
„ Membership badges used		190 9 6
„ Legal advice, etc.		20 6 6
„ Subscription to International Union for the Protection of Nature		5 0 0
„ Typing etc., by outside offices		52 10 0
[*11,041 8 0*]	-	£12,546 7 9

INCOME

	£ s. d.	£ s. d.
By Membership subscriptions		6,076 2 1
„ Sale of Publications:		
"The Advancement of Science"	583 14 3	
Other items	108 7 6	
		692 1 9
„ Advertisements in B.A. publications:		
"The Advancement of Science"	682 15 1	
Preliminary Programme, 1952	230 18 9	
Programme, 1952	415 12 1	
		1,329 5 11
„ Income Tax recovered to 31st March, 1952:		
On Interest and Dividends	20 8 6	
„ covenanted subscriptions	199 1 10	
		219 10 4
„ Interest on Investments		1,544 3 1
„ Donations (excluding donations to Life Membership Fund, for which see Balance Sheet)		129 6 0
„ Charges for administration of Special Funds		140 4 11
[*10,827 18 2*]		10,130 14 1
By Balance, being excess of Expenditure over Income for the year		2,415 13 8
[*213 9 10*]		
[*11,041 8 0*]		£12.546 7 9

No. 2. Development Fund

An appeal for a Development Fund to be used under the direction of the Council, was made at the Annual Meeting at Dundee in 1947. The fund is still open.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£	s.	d.
	Investments at cost :			
	£2,745 19*s.* 0*d.* London County 2½ per cent. Consolidated Stock, 1960/70	2,750	0	0
	£2,679 1*s.* 6*d.* Bristol Corporation 3 per cent. Redeemable Stock, 1958/63	2,750	0	0
	£454 11*s.* 6*d.* 3 per cent. London County Consolidated Stock, 1956/61	452	6	0
	£292 15*s.* 3*d.* Consolidated 2½ per cent. Stock	200	0	0
	[*Value of stocks at 31/3/52, £5,148 7s. 1d.*] (Value at 31/3/53, £5,452 19*s.* 8*d.*)			
[*6,152 6 0*]		£6,152	6	0
	Cash at bank	£377	1	0

EXPENDITURE

	£	s.	d.
To Administration charge [*17 9 8*]	17	13	8
„ Balance, being excess of Income over Expenditure for the year [*157 6 10*]	179	2	11
[*174 16 6*]	£196	16	7

INCOME

	£	s.	d.
By Dividends and Interest	138	13	1
„ Income Tax recovered	38	3	6
„ Donation	20	0	0
[*174 16 6*]	£196	16	7

No. 3. Caird Fund

The unconditional gift of Sir James Caird, in 1912, administered by the Council in accordance with recommendations adopted by the General Committee in 1913.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£	s.	d.
	Investments at cost :			
	£2,904 11*s.* 8*d.* British Gas 3 per cent. Stock, 1990/95	2,209	13	0
	£2,716 16*s.* 6*d.* 3½ per cent. War Loan Inscribed Stock	2,516	15	5
	£4,282 18*s.* 9*d.* 3 per cent. British Transport Stock, 1978/88	4,785	1	6
	£585 10*s.* 6*d.* Consolidated 2½ per cent. Stock	400	0	0
	[*Value of stocks at 31/3/52, £7,950 13s. 6d.*] (Value at 31/3/53, £8,280 15*s.* 0*d.*)			
[*10,328 17 9*]		£9,911	9	11
	Cash at bank	£168	10	2

EXPENDITURE

	£	s.	d.	£	s.	d.
To Rent of tables for 1953 at Biological Stations:						
Naples Zoological Station	50	0	0			
Freshwater Biological Association, Windermere	50	0	0			
Marine Biological Association, Plymouth	50	0	0			
				150	0	0
„ Grants to Research Committees:						
Kent's Cavern	10	0	0			
Dredging in Lough Ine	50	0	0			
Science and Industry	77	19	0			
				137	19	0
„ Administration charge				26	2	2
[*250 18 5*]				314	1	2
„ Balance, being excess of Income over Expenditure for the year [*64 19 7*]				–	–	–
[*315 18 0*]				£314	1	2
Grants authorised, not yet drawn :—						
Demography, etc., in Inter-Tropical Africa	5	0	0			
Glossary of Geographical Terms	5	0	0			
Kent's Cavern	10	0	0			
Plus Further expenses of Committee on Science and Industry, not yet determinable	–	–	–			
[*43 16 8*]	£20	0	0			

INCOME

	£	s.	d.
By Dividends and Interest	200	1	0
„ Income Tax recovered	61	0	8
„ Unexpended balance of grant returned by Committee on Glossary of Geographical Terms		16	0
[*315 18 0*]	261	17	8
„ Balance, being excess of Expenditure over Income for the year [– – –]	52	3	6
[*315 18 0*]	£314	1	2

No. 4. Toronto University Presentation Fund

A fund voluntarily subscribed by members present at the Toronto Meeting in 1924. From the income a presentation of two bronze medals each year is made, together with presents of books, to selected students in pure and applied science respectively.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost :	
	£175 0s. 0d. 3½ per cent. War Stock . . .	178 11 4
	[*Value of stock at 31/3/52, £136 10s. 0d.*] (Value at 31/3/53, £140 17s. 6d.)	
£178 11s. 4d.]		£178 11 4
	Cash at bank	£4 18 0

EXPENDITURE	£ s. d.		INCOME	£ s. d.
To Cost of medals for 1952	2 7 6		By Interest	6 2 6
„ Presents of books, through Toronto University .	3 5 6		By Balance, being excess of Expenditure over Income for the year	2 9
„ Administration charge	12 3			
[*6 4 0*]	£6 5 3	[*6 4 0*]		£6 5 3

No. 5. Bernard Hobson Fund

The bequest of Mr. Bernard Hobson, 1933 ; the income to be applied to the promotion of geological research ; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£50 0s. 0d. 4 per cent. Victory Bonds . .	55 10 5
	£601 9s. 0d. 2½ per cent. Treasury Stock, 1975 or after	601 9 0
	£416 0s. 11d. 3½ per cent. War Stock (Inscribed) .	436 3 1
	£178 16s. 4d. Consolidated 2½ per cent. Stock (Registered)	150 0 0
	[*Value of stocks at 31/3/52, £826 4s. 11d.*] (Value at 31/3/53, £847 16s. 5d.)	
[*1,243 2 6*]		£1,243 2 6
	Cash at bank	£163 2 8

EXPENDITURE	£ s. d.		INCOME	£ s. d.
To Grant to Palaeontographical Society towards publication of Directory of Fossiliferous Localities	150 0 0		By Interest . . . . . [*36 1 2*]	36 1 2
„ Administration charge . . . . . [*3 12 1*]	3 12 1		„ Balance, being in excess of Expenditure over Income for the year . . . . . [– – –]	117 10 11
	£153 12 1			
„ Balance, being excess of Income over Expenditure for the year . . . . . [*32 9 1*]	– – –			
[*36 1 2*]	£153 12 1	[*36 1 2*]		£153 12 1
Grants authorised, not yet drawn :— Critical Geological Sections £30 0 0				
[*30 0 0*]	£30 0 0			

No. 6. Leicester and Leicestershire Fund, 1933

The unexpended balance of the local fund for the Leicester Meeting in 1933, presented to the Association, the interest to be used in assisting by scholarships or otherwise students working for the advancement of science ; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£487 2s. 11d. 3½ per cent. Conversion Stock .	500 0 0
	£490 5s. 11d. 3½ per cent. War Stock . .	500 0 0
	[*Value of stocks at 31/3/52, £762 7s. 11d.*] (Value at 31/3/53, £781 19s. 4d.)	
[*1,000 0 0*]		£1,000 0 0
	Cash at bank	£154 3 8

EXPENDITURE	£ s. d.		INCOME	£ s. d.
To Grant . . . . . [*75 0 0*]	30 0 0		By Interest . . . . . [*34 4 2*]	34 4 2
„ Administration charge . . . . . [*3 8 5*]	3 8 5		„ Balance, being excess of Expenditure over Income for the year . . . . . [*44 4 3*]	– – –
„ Balance, being excess of Income over Expenditure for the year . . . . . [– – –]	15 9			
78 8 5]	£34 4 2	[*78 8 5*]		£34 4 2

No. 7. Radford Mather Lecture Fund

A gift of £250 received from Mr. G. Radford Mather in 1936 to establish a Fund, the income therefrom to be devoted to meeting the expense of triennial Lectures on Recent Advances in Science and their relation to the Welfare of the Community.

(*Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.*)

		£ s. d.
	Investment at cost:	
	£248 17*s.* 8*d.* 3 per cent. London County Consolidated Stock, 1956/61	250 0 0
	[*Value of stock at 31/3/52, £230 4s. 4d.*] (Value at 31/3/53, £240 3*s.* 5*d.*)	
[*250 0 0*]		£250 0 0
	Cash at bank	£42 13 9

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Administration charge [*14 11*]	14 11	By Interest	7 9 4
„ Balance, being excess of Income over Expenditure for the year [*6 14 5*]	6 14 5		
[*7 9 4*]	£7 9 4	[*7 9 4*]	£7 9 4

No. 8. Arthur Haydock Bequest

A bequest received in 1945 "for the purpose of original investigation of problems relating to either or both of Geology or Botany as may be determined by the governing body of the British Association."

(*Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.*)

		£ s. d.
	Investments at cost:	
	£2,090 4*s.* 0*d.* 3½ per cent. Conversion Stock (Registered)	2,215 12 0
	£362 6*s.* 3*d.* Consolidated 2½ per cent. Stock (Inscribed)	250 0 0
	[*Value of stocks at 31/3/52, £1,845 18s. 7d.*] (Value at 31/3/53, £1,879 1*s.* 11*d.*)	
[*2,465 12 0*]		£2,465 12 0
	Cash at bank	£243 6 5

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Grants to Research Committees: [*10 0 0*]		By Interest	82 4 4
Committee on Cytology and Genetics [– – –]	5 6		
Administration charge [*8 4 5*]	8 4 5		
„ Balance, being excess of Income over Expenditure for the year [*63 19 11*]	73 14 5		
[*82 4 4*]	£82 4 4	[*82 4 4*]	£82 4 4

No. 9. Corcoran Gift

A gift of £100 received in 1946 for research in memory of Miss J. R. Corcoran.

(*Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.*)

		£ s. d.
	Investment at cost:	
	£144 18*s.* 6*d.* Consolidated 2½ per cent. Stock	100 0 0
	[*Value of stock at 31/3/52, £86 4s. 7d.*] (Value at 31/3/53, £86 19*s.* 1*d.*)	
[*100 0 0*]		£100 0 0
	Cash at Bank	£9 15 3

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Administration charge	7 3	By Interest	3 12 4
„ Balance, being excess of Income over Expenditure for the year	3 5 1		
[*3 12 4*]	£3 12 4	[*3 12 4*]	£3 12 4

No. 10. Down House

In response to an appeal made in 1927 by Sir Arthur Keith, F.R.S., then President of the British Association, Mr. (later Sir) Buckston Browne, F.R.C.S., acquired the property of Down House, formerly the home of Darwin, and transferred it with an endowment of £20,000 to the Association expressing the wish that it be held in custody for the nation as a memorial to Darwin.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.	
	Investments at cost :		
	£3,000 Fishguard and Rosslare Railway and Harbours 3½ per cent. Guaranteed Preference Stock	2,139 17 3	
	£9,405 8*s.* 9*d.* Consolidated 2½ per cent. Stock	7,608 9 7	
	£1,128 9*s.* 11*d.* 3 per cent. Redemption Stock, 1986/96 (Registered)	1,153 19 7	
	£4,222 13*s.* 1*d.* 3 per cent. British Transport Stock, 1978/88	3,118 1 4	
	Value of stocks at 31/3/52, £15,188 2s. 6d.] (Value at 31/3/53, £12,064 0*s.* 3*d.*)		
[17,698 4 0]		£14,020 7 9	

EXPENDITURE				INCOME			
	£	*s.*	*d.*		£ *s.* *d.*	£ *s.*	*d.*
To Wages of Staff	1,135	2	2	By Rents receivable		98 0	0
„ Rates, Insurance, etc.	39	4	6	„ Income Tax recovered to 31st March, 1952		155 1	0
„ Electricity	46	3	2	„ Dividends and Interest		460 1	11
„ Fuel, etc.	152	6	8	„ Sale of catalogues, postcards and photographs		13 4	0
„ Drainage, including cost of sewer extension	957	0	6	„ Donations received		56 14	6
„ Water	25	10	0	„ Sale of surplus produce		11 16	0
„ Repairs and Renewals	23	11	11				
„ Land and Garden : materials and maintenance (see opposite)	89	9	9	*[804 6 0]*		794 17	5
„ Household requisites, etc.	16	8	7				
„ Printing, postage, telephone, stationery	38	4	1	„ Balance, being excess of Expenditure over Income for the year, transferred to Endowment Fund.		2,108 19	10
„ Carriage		5	6	*[906 18 9]*			
„ Architects' fees, legal charges, etc.	297	7	5				
„ Hospitality	3	13	3				
„ Administration charge	79	9	9				
[1,711 4 9]	£2,903	17	3	*[1,711 4 9]*		£2,903 17	3

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September 2–9, 1953

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